Total Maximum Daily Load (TMDL) Status Report
Powder River TMDL Planning Area

March 14, 2003

Department of
Environmental Quality

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Prepared for the Montana Department of Environmental Quality by Tetra Tech, Inc.
Technical support and direction provided by the U.S. Environmental Protection Agency

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ACRONYM LIST

ARM	Administrative Rules of Montana
BEHI	Bank erosion hazard index
BLM	Bureau of Land Management
CBM	Coal bed methane
CFS	Cubic feet per second
CV	Coefficient of variation
DO	Dissolved oxygen
EC	Electrical conductivity
EIS	Environmental Impact Statement
GAP	Gap analysis project
GIS	Geographic information system
MDEQ	Montana Department of Environmental Quality
MLRA	Major land resource area
MRLC	Multi-Resolution Land Characterization
NASS	National Agricultural Statistics Service
NCEPD	Northern Cheyenne Environmental Protection Department
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity units
NWIS	National Water Information System
SAR	Sodium adsorption ratio
SC	Specific conductance
SDDENR	South Dakota Department of Environment and Natural Resources
STATSGO	State Soil Geographic Database
TDS	Total dissolved solids
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TPA	TMDL planning area
TR	Total Recoverable
TRWU	Tongue River Water Users
TSI	Trophic state index
TSS	Total suspended solids
T&Y	Tongue and Yellowstone Irrigation District
USDI	United States Department of Interior
USEPA	United State Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
WDEQ	Wyoming Department of Environmental Quality
WRCC	Western Regional Climate Center
WWDC	Wyoming Water Development Commission

1.0 INTRODUCTION

1.1 Background

The Powder River watershed encompasses approximately 13,045 square miles in the states of Wyoming and Montana. The headwaters originate in north central Wyoming and flow to the northeast into southeastern Montana. Approximately 70 percent of the watershed lies in Wyoming, while 30 percent is in Montana. Major tributaries include the Little Powder River, Crazy Woman Creek, Clear Creek, and Mizpah Creek. The Powder River has a total length of about 464 miles of which 220 miles flow through Montana to its confluence with the Yellowstone River near Terry in Prairie County. In Montana, the Powder River follows a winding course through a relatively narrow valley bounded by rolling benches. The Powder River is one of four major tributaries to the Yellowstone and has the second largest drainage area of any Yellowstone tributary, making up nearly 20 percent of the Yellowstone watershed drainage area. However, it contributes only 5 percent of the average annual flow of the Yellowstone River.

The focus of this document is on the portion of the Powder River watershed within the state of Montana. This area is referred to as the Powder River Total Maximum Daily Load (TMDL) Planning Area (TPA) and specifically includes the main stem of the Powder River, the Little Powder River, Mizpah Creek, and Stump Creek. Although the focus of this document is on the portion of the Powder River watershed within the state of Montana, the relevant physical, chemical, and biological characteristics within the entire watershed, including all tributaries, are considered herein.

Stream segments designated as “water quality impaired” or “threatened” are listed on Montana’s 303(d) list and require the development of TMDLs. Within the Powder River TPA, the Powder River, Little Powder River, Mizpah Creek, and Stump Creek are all listed as impaired on the 1996 303(d) list (see Section 3.0 for details regarding the 303(d) list status of these waterbodies). On September 21, 2000, the United States District Court of Montana ordered the U.S. Environmental Protection Agency (USEPA) to work with the Montana Department of Environmental Quality (MDEQ) to develop and adopt a schedule to develop all necessary TMDLs for waters on Montana’s 1996 Section 303(d) list by May 5, 2007. See, Friends of the Wild Swan, Inc. et al., vs. U.S. Environmental Protection Agency, CV 97-35-M-DWM. In accordance with the original schedule, all necessary TMDLs for the Powder River TPA were to be completed by December 31, 2006. However, the MDEQ has decided to accelerate the schedule for this TPA to facilitate coordination between the TMDL program and ongoing efforts relative to development of coal-bed methane (CBM). As will be described below in Section 1.3, interim, framework TMDLs may be completed as early as June/July 2003. However, the final target date for completion of all necessary TMDLs for this TPA is December 31, 2003.

The TMDL process identifies the maximum load of a pollutant (e.g., sediment, nutrient, metals) a waterbody is able to assimilate and fully support its designated uses, allocates portions of the maximum load to all sources, identifies the necessary controls that may be implemented voluntarily or through

COAL-BED METHANE (CBM)

Coal-bed methane production has rapidly increased throughout the United States in the past several years. USGS estimates that methane gas extracted from coal seams now accounts for 7.5 percent of the natural gas production in the U.S. (USGS, 2000). Extracting methane gas from coal seams is a relatively new and simple process. Large quantities of methane gas are found in coal beds. The methane is trapped in the coal beds because of pressure and the coal’s high internal surface area. During CBM extraction, water is pumped out of the coal bed to reduce the pressure, thereby allowing methane to escape. The methane is collected and the water is disposed of to either the surface or subsurface.

The Montana Bureau of Land Management (BLM) estimated that 659 square miles (16 percent) of land in the Powder River watershed in Montana has the potential to produce CBM (USDI, 2001). It is estimated that the potential maximum number of wells in this area is 5,397 wells. Assuming that the maximum number of wells are installed, and they operate for 20 years, the BLM estimated that as much as 4.8 billion gallons of water would be discharged into the Powder River watershed over the life of the wells. This potentially enormous volume of water, as well as the constituents in the water, could have adverse affects on water resources in the Powder River watershed.

regulatory means, and describes a monitoring plan and associated corrective feedback loop to insure that uses are fully supported. A TMDL can also be viewed as the total amount of pollutant that a waterbody may receive from all sources without exceeding water quality standards. Montana's approach is to include TMDLs as a part of a comprehensive water quality restoration plan containing seven principal components:

1. Watershed characterization (e.g., hydrology, climate, vegetation, land use, ownership)
2. Description of impairments and applicable water quality standards
3. Pollutant source assessment and estimate of existing pollutant loads
4. Water quality goals (i.e., water quality targets and TMDLs)
5. Allocation
6. Restoration strategy
7. Monitoring strategy

MDEQ has chosen a phased approach for the establishment of TMDLs in the Powder River TPA. The phased approach has been selected to accommodate the following issues:

1. The intent of the TMDL program is to attain and maintain compliance with water quality standards. In fact, water quality standards are the basis from which TMDLs are established and the TMDL targets are derived. The Montana Board of Environmental Review (the Board) is considering adoption of numeric water quality standards for sodicity (as sodium adsorption ratio, SAR) and salinity (as electrical conductivity, EC) for the Tongue River, Powder River, Little Powder River and Rosebud Creek watersheds to address current and projected development of CBM within these watersheds. As currently planned, the Board is not scheduled to make their final decision regarding adoption of numeric water quality standards until March 28, 2003, at the earliest. If the Board adopts numeric water quality standards, they will form the basis for establishment of TMDLs in the Powder River TPA. If the Board does not adopt them, the existing narrative standards will have to be interpreted to derive TMDLs and TMDL numeric targets. Given the above described schedule and the interrelationship between the state's standards and TMDL programs, it is not possible to proceed with a final TMDL until final decisions have been made regarding the adoption of numeric criteria.

2. Typically, in the TMDL process, when numeric water quality standards are available for a pollutant of concern, they are used to make water quality impairment determinations and form the basis for numeric water quality targets. For example, if the numeric water quality standard is exceeded a certain percent of the time, the waterbody is considered impaired.

   MDEQ has proposed the establishment of numeric water quality standards for EC and SAR specific to the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries. While MDEQ's proposal may result in establishment of numeric water quality standards (e.g., 1900 µS/cm EC in the Little Powder River), the provisions of 75-5-306 MCA provide that "*It is not necessary that wastes be treated to a purer condition than the natural condition of the receiving stream so long as the minimum treatment requirements established under this chapter are met*."

   Natural refers to "*conditions or materials present in the runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been employed*."

The provisions of 75-5-306 MCA make it impossible to use MDEQ's numeric criteria for making a Clean Water Act 303(d) water quality impairment determination without first defining the natural condition of the receiving stream.

3. While in most cases sufficient data are available to describe ambient water quality conditions, there are currently insufficient site-specific monitoring data to define the natural condition (i.e., to what extent the existing water quality is a function of natural versus human-caused activities) of the waters within the Powder River TPA or to derive appropriate TMDL targets that are both protective of beneficial uses and reflect the water quality potential of the subject waterbodies.

4. In most cases, for most non-CBM related pollutants (e.g., nutrients, sediment, pathogens) in most 303(d) listed waters within the Powder River TPA, insufficient site-specific data exist to determine water quality impairment status and/or establish appropriate TMDL targets.

Each of the above issues necessitates a phased TMDL approach where additional time is provided to collect supplemental water quality data and the Board is provided time to make final decisions regarding the adoption of numeric water quality criteria.

1.2 Document Purpose and Content

This document presents the results of the first phase of TMDL development for the Powder River TPA. The purpose of this document is to provide a summary and status report of the TMDL-related work that has been performed to date, completes the first component of the TMDL process as defined above (i.e., Watershed Characterization), and preliminarily completes the second component of the process (i.e., Water Quality Impairment Status). This is a status report and comments from all interested parties are welcomed. Although MDEQ will not be preparing a revised version of this status report, all data and comments will be considered during the preparation of the final TMDLs.

This phase began almost two years ago when MDEQ began working with the Carter, Custer, Rosebud, Powder, Bighorn, and Prairie County Conservation Districts, with USEPA funding, for the collection of water quality data in waterbodies within the TPA. The work has been conducted under the direction of MDEQ with technical assistance from USEPA and contractor support from Tetra Tech, Inc. The intent of Phase I is to develop a thorough understanding of the existing environment as it relates to water quality and to compile and evaluate all available water quality data to describe ambient water quality conditions. The physical, chemical, and biological characteristics of the environment in which the subject waterbodies exist are described in Section 2 – Watershed Characterization. A summary and evaluation of all available water quality information is presented in Section 3 – Water Quality Impairment Status. Section 3 also discusses identified data gaps. A monitoring plan to fill the identified data gaps is presented in Section 4 – Monitoring Strategy.

1.3 Future Phases

Phase I will provide the foundation upon which to make water quality impairment determinations and establish all necessary TMDLs for the Powder River TPA. As such, this Phase I report is a status report and a subset of the final TMDL report. All available information at the time of this report was used in the analyses and conclusions. Additional data and comments applicable to all phases of the TMDL process will continue to be acquired and used. Subsequent phases of the TMDL process will build upon the information presented in this report to establish appropriate targets, and source allocations. Potentially, two additional phases will be initiated. These are described in the following paragraphs.

1.3.1 Phase II – Interim Framework TMDLs

The previously mentioned court order not only stipulated that USEPA and the state work together to develop and implement a schedule for completing all necessary TMDLs, but went on to state that "*Until all necessary TMDLs are established for a particular water quality limited segment, the EPA shall not issue any new permits or increase permitted discharges for any permittee under the National Pollutant Discharge Elimination System permitting program or under the Montana Pollutant Discharge Elimination System*." In other words, this stipulates that the state or USEPA can permit no new or increased discharges until all necessary TMDLs are completed.

Phase II would be optionally implemented at MDEQ's discretion in an attempt to avoid permitting delays that might be forced as a result of this court-ordered stipulation. Phase II could be completed within approximately two to three months of a decision by the Board to adopt, or not adopt, numeric water quality criteria (e.g., a draft Phase II TMDL document completed in June/July 2003 assuming the Board makes a final decision on March 28, 2003).

Phase II would use all currently available information to develop framework TMDLs for CBM-related parameters and would establish interim numeric water quality targets, TMDLs, and allocations that would be "in effect" until Phase III is completed in December 2003. The Phase II process would facilitate immediate protection of beneficial uses using the best available data and may allow for some discharges of CBM-related parameters in some waters while additional data are collected, and analyses are conducted in Phase III to refine final targets and TMDLs.

MDEQ's decision to proceed with Phase II will be based on: (1) permit applications for proposed CBM discharges, and (2) the period of time over which the Phase II interim, framework TMDL would be in effect. If factors other than the TMDL process continue to drive the CBM development issue (e.g., the Environmental Impact Statement or delays in the decision to adopt numeric water quality criteria) there may be no need to proceed with Phase II given that the Phase III process is scheduled for completion by December 31, 2003. On the other hand, if it appears that the court-ordered stipulation would drive the CBM development issue, it may be prudent for the state to proceed with Phase II to avoid permit delays.

1.3.2 Phase III – Final TMDLs

The need for additional data collection is described above in Section 1.1. Phase III has been proposed to facilitate the collection of additional data and to provide additional time to apply the appropriate analytical tools to ultimately complete all seven components of the TMDL process based on the best available, up-to-date water quality data.

Phase III is intended to result in the establishment of all necessary, final TMDLs for all pollutant/ waterbody combinations appearing on the 1996 303(d) list. Phase III will fill data gaps identified in Phase I through implementation of a rigorous monitoring program, establish final numeric targets based on the newly acquired data and application of appropriate analytical tools (e.g., models), apply the final targets to develop final TMDLs and allocations for CBM-related parameters, and to establish all necessary TMDLs for all of the non-CBM related pollutants appearing on the 1996 303(d) list. The target completion date for Phase III is December 31, 2003, assuming that favorable/representative weather conditions exist in the spring and summer of 2003 for the collection of the necessary supplemental monitoring data.

2.0 WATERSHED CHARACTERIZATION

The intent of this section of the document is to put the subject water bodies into context with the watershed in which they occur. This section provides the reader with a general understanding of the environmental characteristics of the watershed that may have relevance to the 303(d) listed water quality impairments. This section also provides some detail regarding those characteristics of the watershed that may play a significant role in driving pollutant loading (e.g., geographical distribution of soil types, vegetative cover, land use, etc.). The information provided in this section is provided for context. A more detailed consideration of some of this information, at a finer scale, will likely be included in the final TMDL document.

2.1 Physical Characteristics

2.1.1 Location

The Powder River watershed traverses the states of Wyoming and Montana, encompassing an area of approximately 13,405 square miles. Bounded by the Big Horn Mountains on the southwestern margin of the watershed, the headwaters of the Powder River originate in north central Wyoming, and the river flows generally to the northeast into southeastern Montana toward its confluence with the Yellowstone River as shown in Figure 2-1. Major tributaries to the Powder River include the Little Powder River, Crazy Woman Creek, Mizpah Creek, and Clear Creek.

Powder River near Locate, Montana
Photograph by Tetra Tech, Inc.

The watershed includes portions of Natrona, Converse, Washakie, Johnson, Campbell, Crook, and Sheridan Counties in Wyoming, and Powder River, Carter, Custer, and Prairie Counties in Montana. Nearly 70 percent of the watershed (roughly 9,354 square miles) lies in Wyoming, while 30 percent (4,051 square miles) is located in Montana. The watershed also includes ten U.S. Geological Survey (USGS) 8-digit hydrologic cataloging units, numbers 10090201 through 10090210.

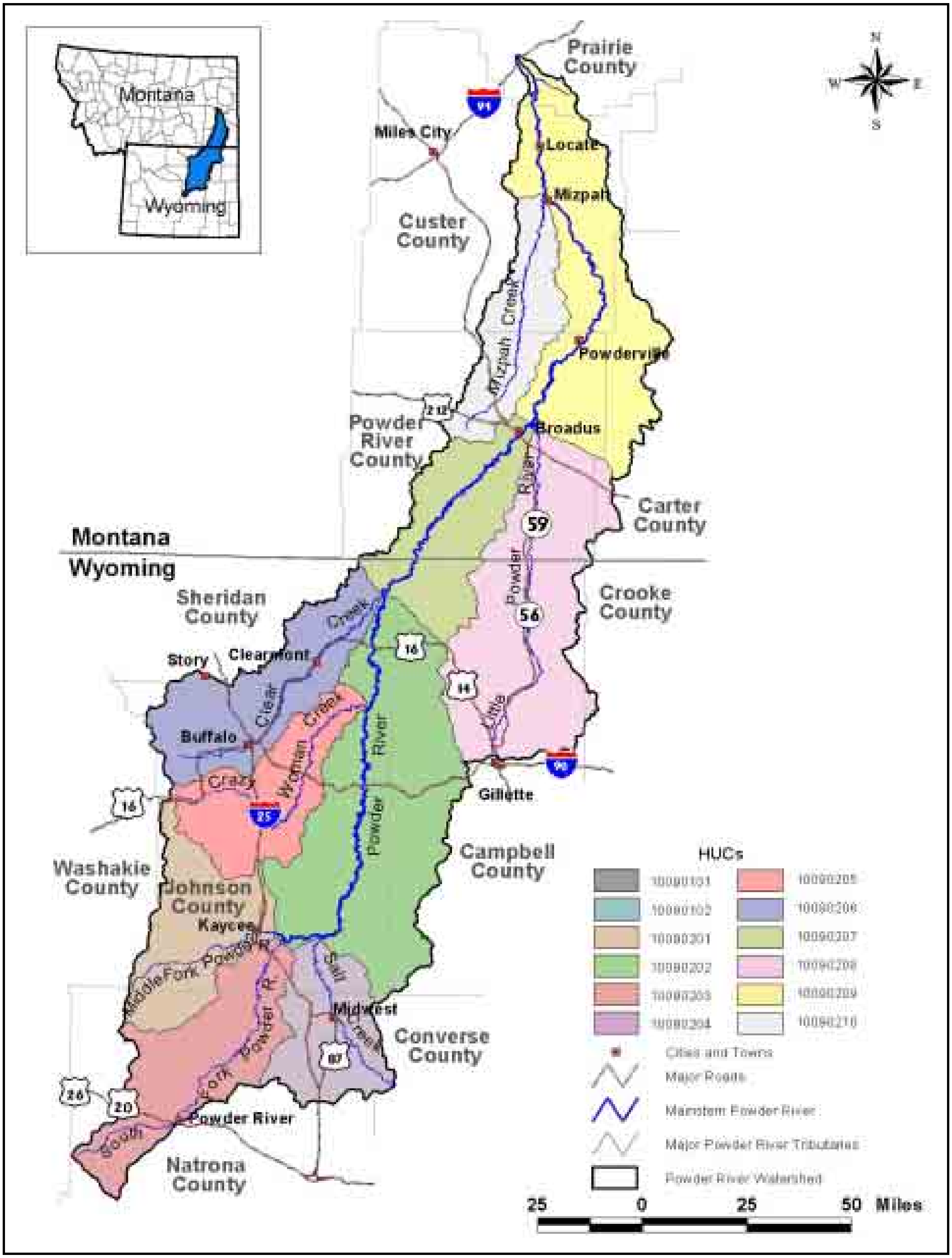

Figure 2-1. Location of the Powder River watershed.

2.1.2 Climate

Climate in the Powder River watershed is characterized by colder and wetter conditions in mountainous areas and temperate to semiarid conditions in lower elevation plains regions. Indeed, annual precipitation and temperature is largely governed by elevation in the Powder River watershed. In mountainous areas, typified by elevations of 6,000 to 13,000 feet above mean sea level (MSL), total annual average precipitation ranges from 14 to 25 inches and is dominated by snowfall (Lindner-Lunsford, et al., 1992). The continental location of the watershed results in a climate that is marked by seasonal variations and extremes in precipitation and temperature. Average monthly precipitation is typically greatest from March to July. Significant snowfall begins in October and continues through May. Temperatures reach their maximum in July, while minimum values occur in January.

The National Oceanic and Atmospheric Administration (NOAA) collects data from many climate stations located within the Powder River watershed as shown in Figure 2-2 and listed in Table 2-1. A graphical summary of the average climatic characteristics at a station is called a climagraph. Figure 2-3 illustrates annual average precipitation and temperature for the Powder River 2 station, Wyoming (NOAA Cooperative station number 487376). This station typifies upland climates in the Powder River watershed, and shows that much of the snowfall occurs from January through April, while most of the precipitation occurs from April through July (WRCC, 2002). Total annual average precipitation and total annual average snowfall at this station are 11.38 inches and 47.6 inches, respectively. Average monthly temperatures range from a maximum of 69.7 °F in July to a minimum of 22.1 °F in January.

In plains regions, with elevations from 3,000 to 6,000 feet above MSL, annual average precipitation ranges from 10 to 14 inches, and rainfall is a more dominant form of the precipitation (Lindner-Lunsford, et al., 1992). Average monthly precipitation is greatest from April through September, and maximum temperatures occur in July, while minimum values occur in January. Figure 2-4 displays a climagraph of the Mizaph 4 NNW station, Montana (NOAA Cooperative station number 245754). This station is located near the confluence of the Powder River and the Yellowstone River, and is typical of lower elevation plains regions in the watershed. The climagraph shows that much of the precipitation occurs from April through September, with May and June being the wettest months. Total annual average precipitation is 12.85 inches, while total annual average snowfall is 28.6 inches (WRCC, 2002). Average monthly temperatures range from a maximum of 72.6 °F in July to a minimum of 15.3 °F in January.

Another important climatic factor for the entire watershed, particularly from a water management perspective, is evaporation rate, which is largely dependent on air temperature, wind speed, and elevation (Reider, 1990). Evaporation is a major water loss, especially in arid and semiarid climates. Total annual evaporation in the Powder River watershed averages around 20 inches in mountainous areas, while lower elevation plains regions average approximately 35 inches. In lower elevation areas, evaporation exceeds precipitation on an annual average basis (WRCC, 2002).

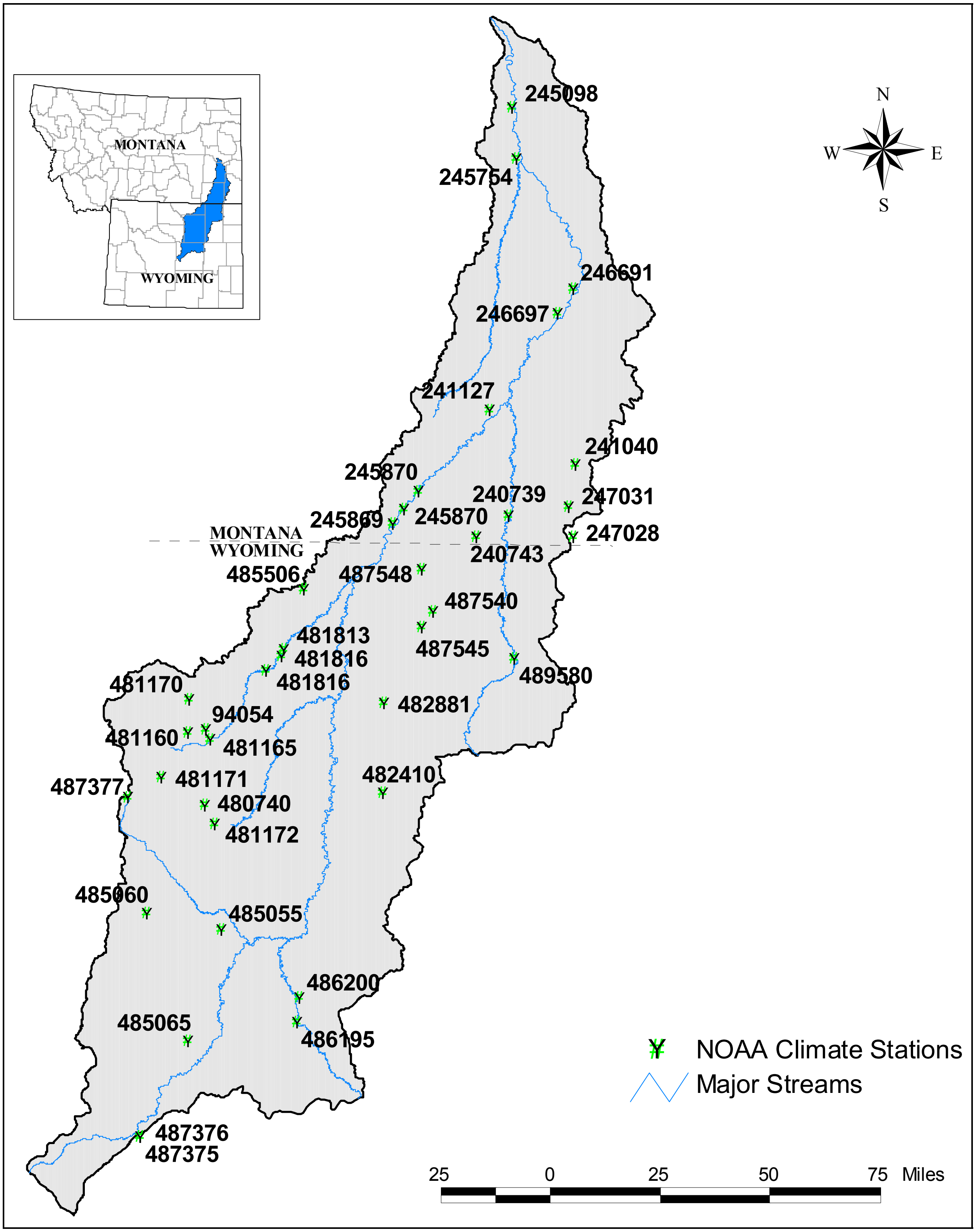

Figure 2-2. Distribution of NOAA climate stations in the Powder River watershed.

Table 2-1. NOAA climate stations located within the Powder River watershed.

Montana			
Station Name	**Coop-ID**	**Period of Record**	**Elevation (ft)**
Biddle	240739	1950-present	3328.2
Biddle 8 SW	240743	1963-present	3596.2
Broadus	241127	1940-present	3031.4
Moorhead	245869	1948-1958	3352.2
Moorhead 5 NE	245870	1958-1963	3201.3
Moorhead 9 NE	245870	1963-present	3219.3
Powderville	246697	1949-1964	2801.1
Ridge 2 WSW	247028	1964-1973	4123.0
Ridge 6 N	247031	1973-1974	3913.0
Boyes	241040	1950-1972	3332.2
Locate	245098	1972-1987	2391.4
Mizpah 4 NNW	245754	1949-present	2479.4
Powderville 8 NNE	246691	1964-present	2799.2
Wyoming			
Station Name	**Coop-ID**	**Period of Record**	**Elevation (ft)**
Powder River No 2	487376	1964-present	5698.7
Powder River Pass	487377	1949-1976	9603.5
Powder River School	487375	1948-present	5692.4
Midwest	486195	1948-present	4858.7
Midwest 6 N	486200	1948-1958	NA
Kaycee	485055	1943-present	4658.9
Kaycee 17 WNW	485060	1949-1958	5661.6
Kaycee 26 SSW	485065	1949-1966	5441.5
Billy Creek	480740	1962-present	4973.8
Dead Horse Creek	482410	1962-1992	4438.8
Buffalo	481165	1931-present	4688.8
Buffalo 11 NW	481170	1949-1954	4962.6
Buffalo 15 SW	481171	1962-1973	8314.8
Buffalo 21 S	481172	1950-1958	4781.9
Buffalo 5 W	481160	1948-1964	5241.8
Buffalo Bill Dam	481175	1948-present	5154.5
Buffalo Johnson County Airport	94054 (WBAN)	1998-present	4965.6
Leiter 9 N	485506	1964-present	4159.0
Clearmont 5 SW	481816	1954-present	3994.1
Clearmont 2 SW	481816	1949-1954	3922.9
Clearmont	481813	1938-1948	3913.0
Echeta 2 NW	482881	1949-present	3999.0
Weston 1E	489580	1951-present	3524.0
Recluse 11 NNW	487548	1966-present	3749.0
Recluse	487545	1931-present	4148.9
Recluse 3 NNE	487540	1948-1966	4202.0

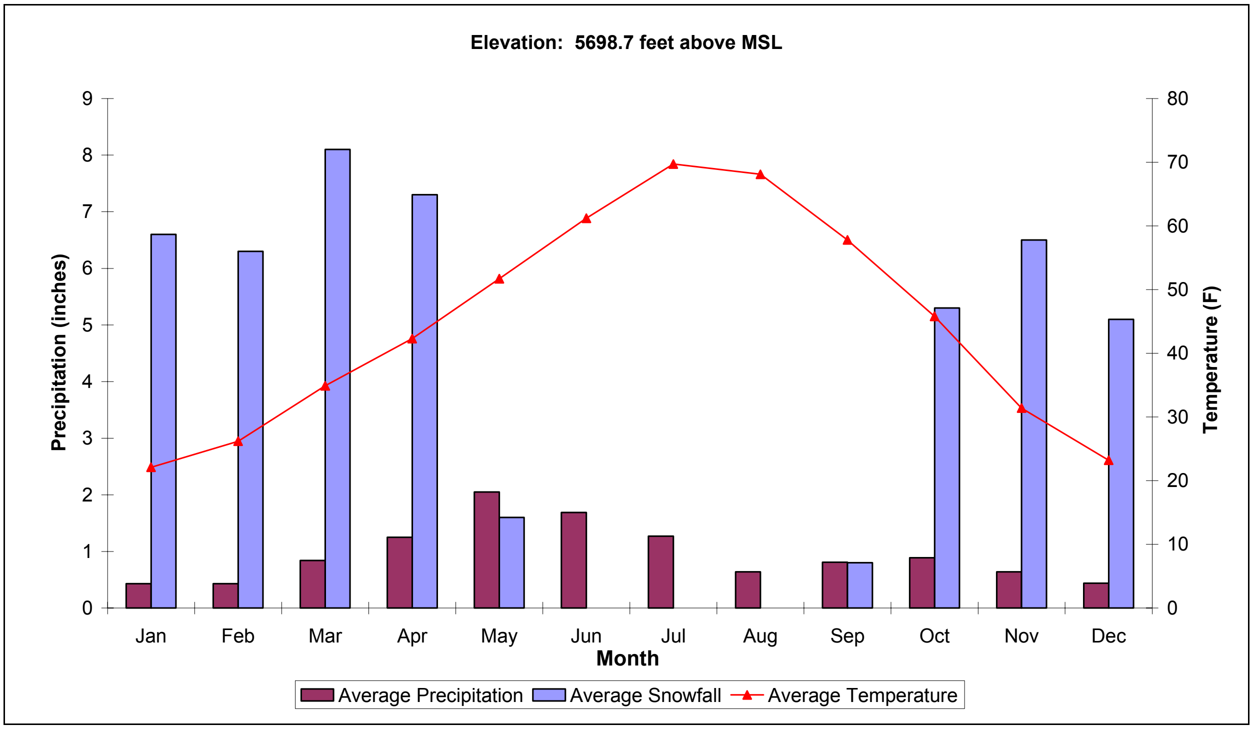

Figure 2-3. Climagraph for Powder River 2, WY, station 487376.

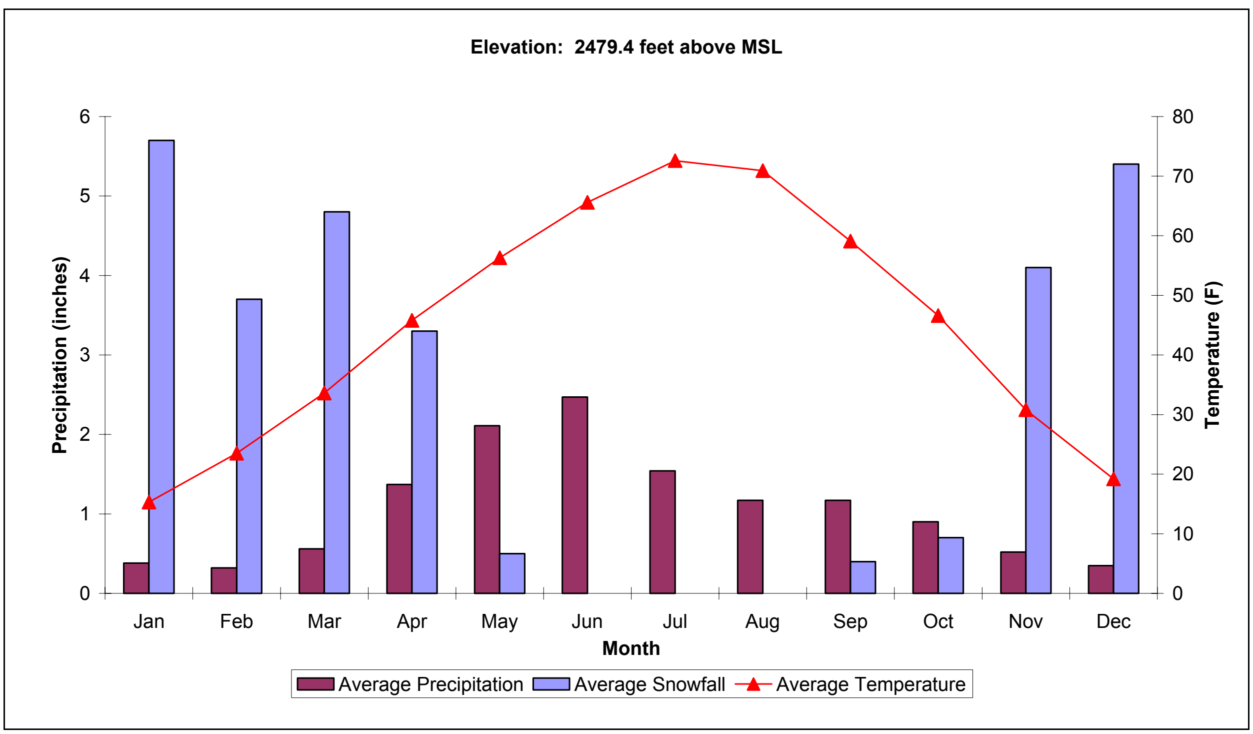

Figure 2-4. Climagraph for Mizpah 4 NNW, MT, station 245754.

2.1.3 Hydrology

2.1.3.1 Powder River Flow Data - Main Stem

The USGS National Water Information System (NWIS) online database lists 62 flow gages with current and historic flow data in the Powder River watershed. Five of the stations on the main stem of the Powder River were analyzed to obtain a general understanding of flow from the headwaters to the mouth at the Yellowstone River. These stations were the Powder River at Locate, MT; Powder River at Broadus, MT; Powder River at Moorhead, MT; Powder River at Arvada, WY; and the Powder River at Sussex, WY. These stations are shown in Figure 2-5 and described in Table 2-2.

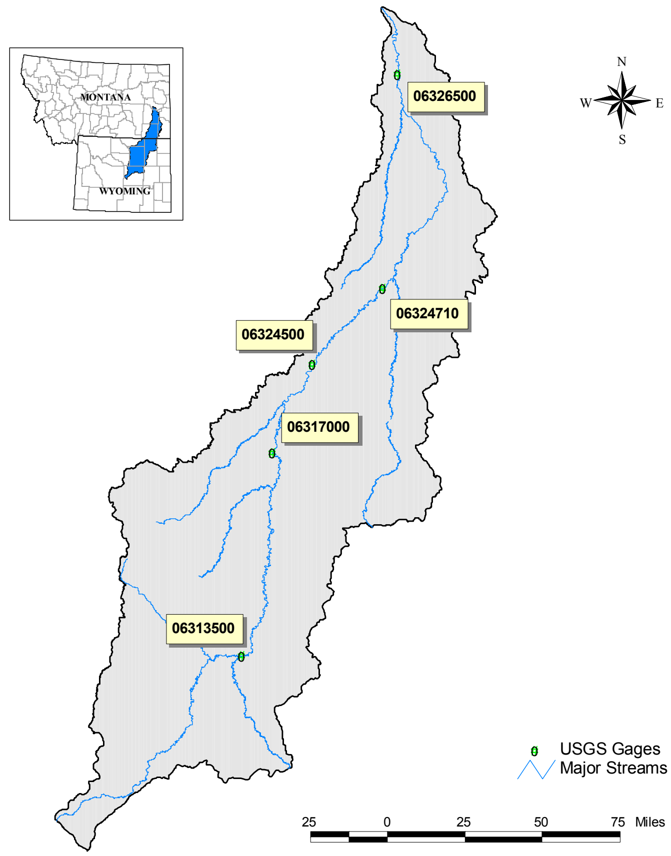

Figure 2-5. Location of selected USGS stations in the Powder River watershed.

The flow patterns at the five main stem stations are very similar. Figure 2-6 shows that there is an increase in flow in February and March that is attributable to snowmelt at lower elevations. Flows then decrease in April and increase again in May due to snowmelt at higher elevations and precipitation. By the end of July, evaporation, reduced precipitation, and withdrawals cause the river to flow at baseflow. Flow slightly increases from upstream to downstream and the most pronounced changes in flow occur during the rainfall and snowmelt season. The high variability in daily flows, exemplified by the upstream stations, occurs because flow in the Powder River watershed is sustained mostly by intense rainstorms and snowmelt (USGS, 1999). Many of the tributaries flowing from the plains regions are ephemeral. However, streams flowing from the mountainous areas are often perennial and sustained by precipitation and yearlong snowmelt.

Table 2-2. Selected USGS stream gages on the main stem of the Powder River.

Station ID	Gage Name	Drainage Area (mi^2)	Period of Record	
			Start Date[a]	End Date[b]
06326500	Powder River at Locate, MT	13,189	1938	Current
06324710	Powder River at Broadus, MT	8,748	1975	1992
06324500	Powder River at Moorhead, MT	8,088	1929	Current
06317000	Powder River at Arvada, WY	6,050	1930	Current
06313500	Powder River at Sussex, WY	3,090	1938	1998

[a]The first year in which continuous flow data are available.
[b]The last year in which continuous flow data are available.

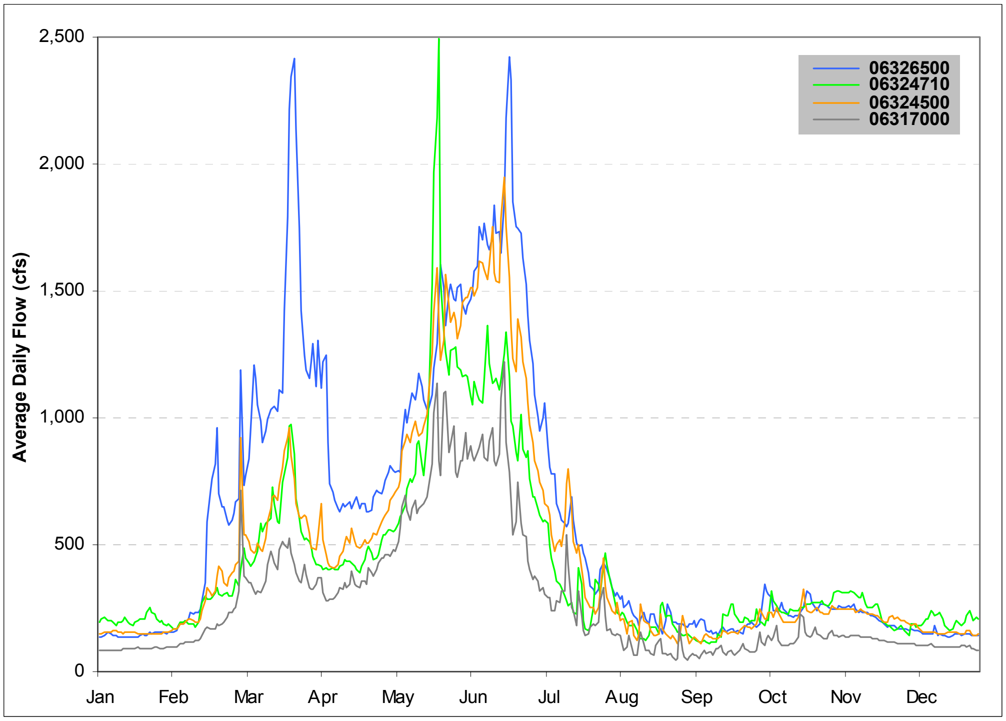

Figure 2-6. Average daily flows at five USGS gages on the main stem of the Powder River (entire period of record is shown).

2.1.3.2 Powder River Flow Data - Tributaries

The USGS National Water Quality Assessment Program (NAWQA) study reports that streams in the Powder River watershed are highly variable (USGS, 1999). Streams that originate in the mountainous regions are generally sustained by snowmelt and have perennial flows. Examples of these streams are the North Fork Powder River, Middle Fork Powder River, and the headwater regions of Crazy Woman Creek and Clear Creek. Figures 2-7 and 2-8 show typical hydrographs of streams in these regions, and Table 2-3 summarizes the characteristics of the selected gages. Flows are high during the major snowmelt period of April through July and then taper off into baseflow for the remainder of the year.

Other streams, such as the Little Powder River and Mizpah Creek flow entirely through the plains region of the Powder River watershed. These streams are usually ephemeral in the headwater areas and flow is controlled by local snowmelt and intense rainstorms (USGS, 1999). Flows are also strongly influenced by withdrawals and returns. Figures 2-9 and 2-10 show the average daily streamflow at two tributary stations that flow through the plains region. Flows tend to vary from day to day with almost no flow occurring during baseflow. Variability in flow is consistent throughout the entire year and also occurs during the spring when the effects of local snowmelt are evident.

Many of the streams in the Powder River watershed are influenced by flow from the plains and mountain regions (Powder River, Crazy Woman Creek, Clear Creek). This combination of both systems results in streamflows that can have significant average daily variability caused by intense rainstorms along with a consistent baseflow maintained by snowmelt from higher elevations. This pattern was observed at the gage located at Crazy Woman Creek (Figure 2-11) and can also been seen in the main stem of the Powder River hydrographs (Figure 2-6).

Table 2-3. Selected USGS gages on tributary streams in the Powder River watershed.

Station ID	Gage Name	Drainage Area (mi^2)	Period of Record Start Date[a]	Period of Record End Date[b]
06324970	Little Powder River near Weston, MT	3,410	1972	Current
06316400/ 06316500	Crazy Woman Creek near Arvada, WY	956	1939	1981
06326300	Mizpah Creek near Mizpah, MT	797	1974	1986
06309500	Middle Fork Powder River above Kaycee, WY	450	1949	1992
06318500	Clear Creek near Buffalo, WY	120	1917	1992

[a]The first year in which continuous flow data are available.
[b]The last year in which continuous flow data are available.

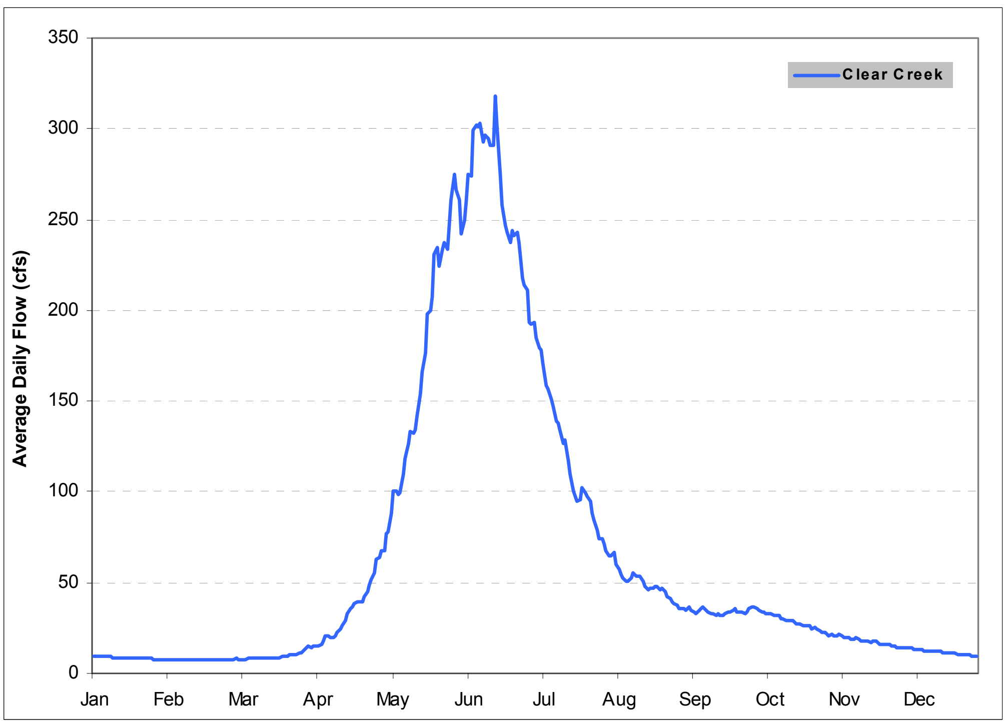

Figure 2-7. Example hydrograph of snowmelt flow regime, Clear Creek (1917-1992).

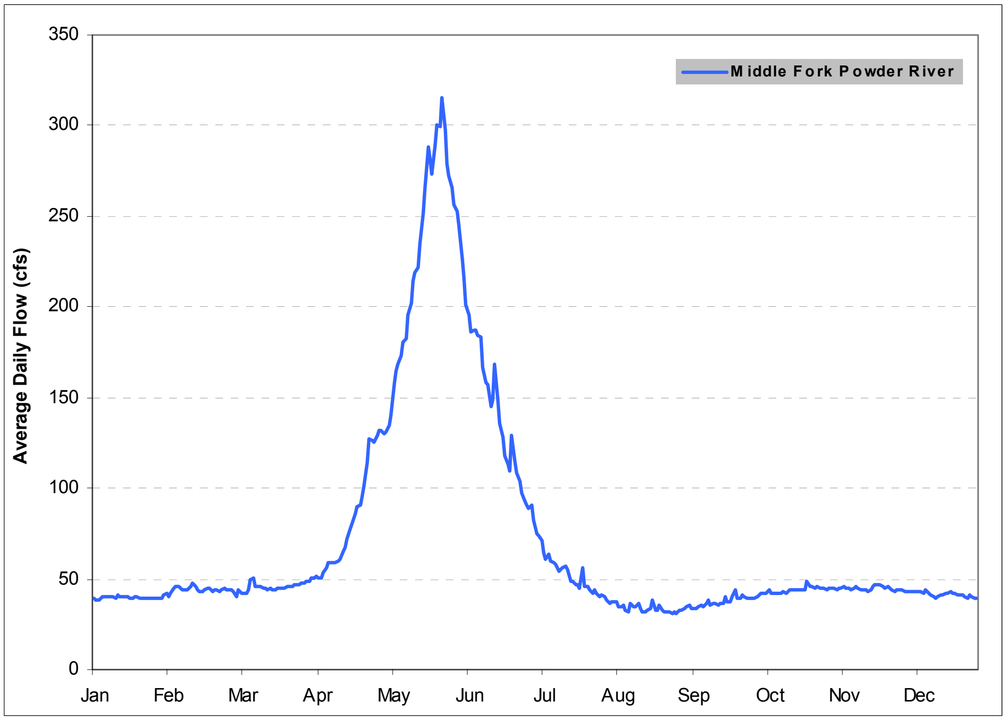

Figure 2-8. Example hydrograph of snowmelt flow regime, Middle Fork Powder River (1949-1992).

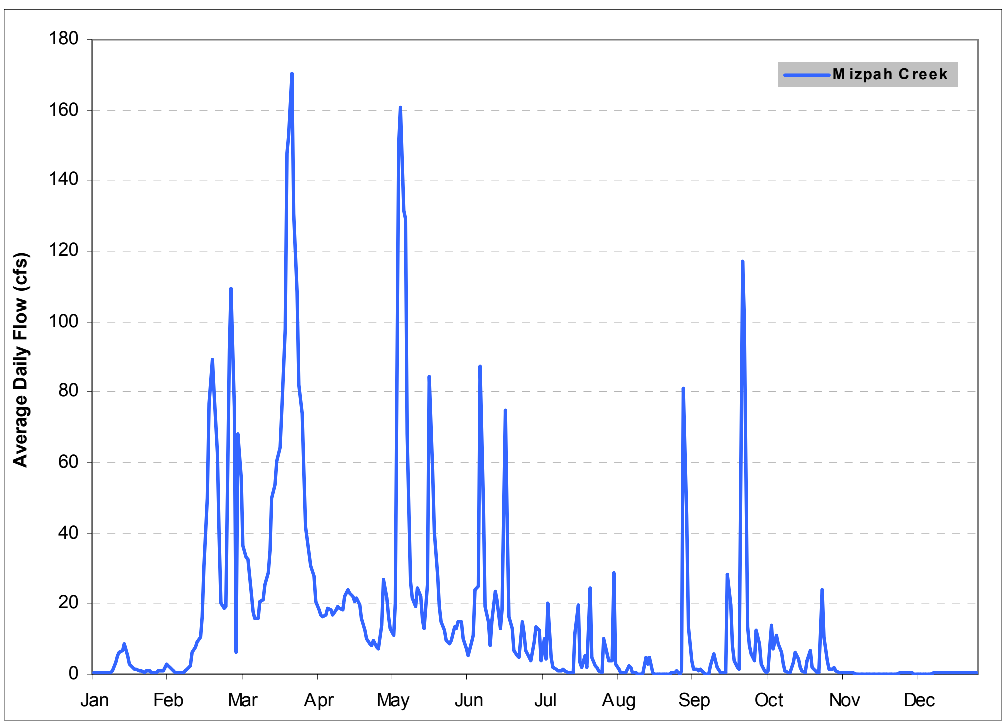

Figure 2-9. Example hydrograph of the plains flow regime, Mizpah Creek (1974-1986).

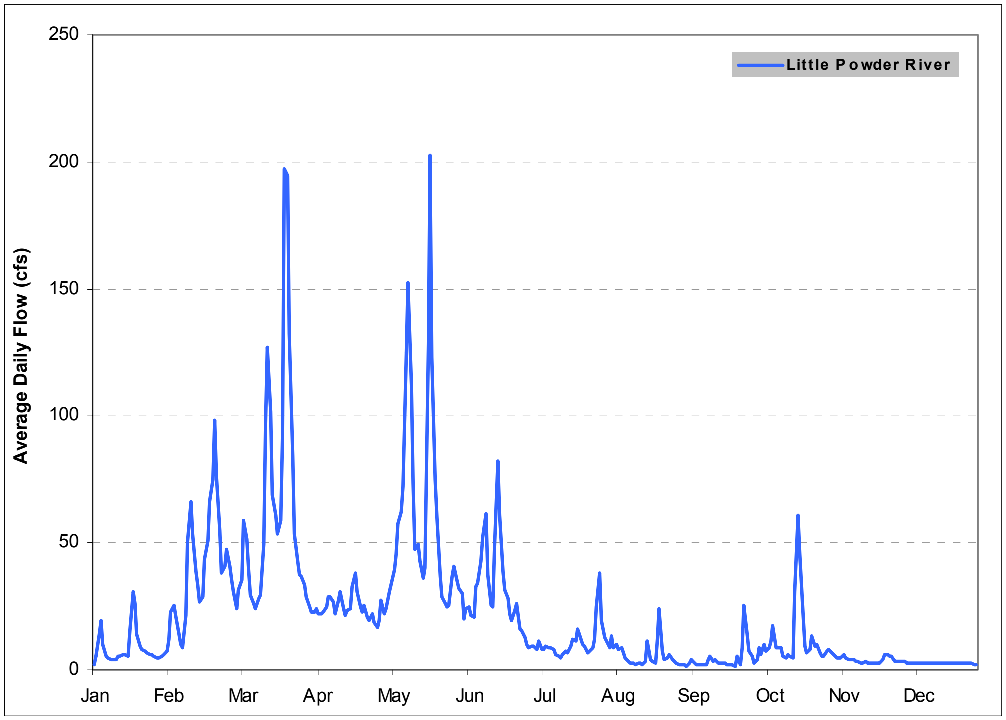

Figure 2-10. Example hydrograph of the plains flow regime, Little Powder River (1972-2000).

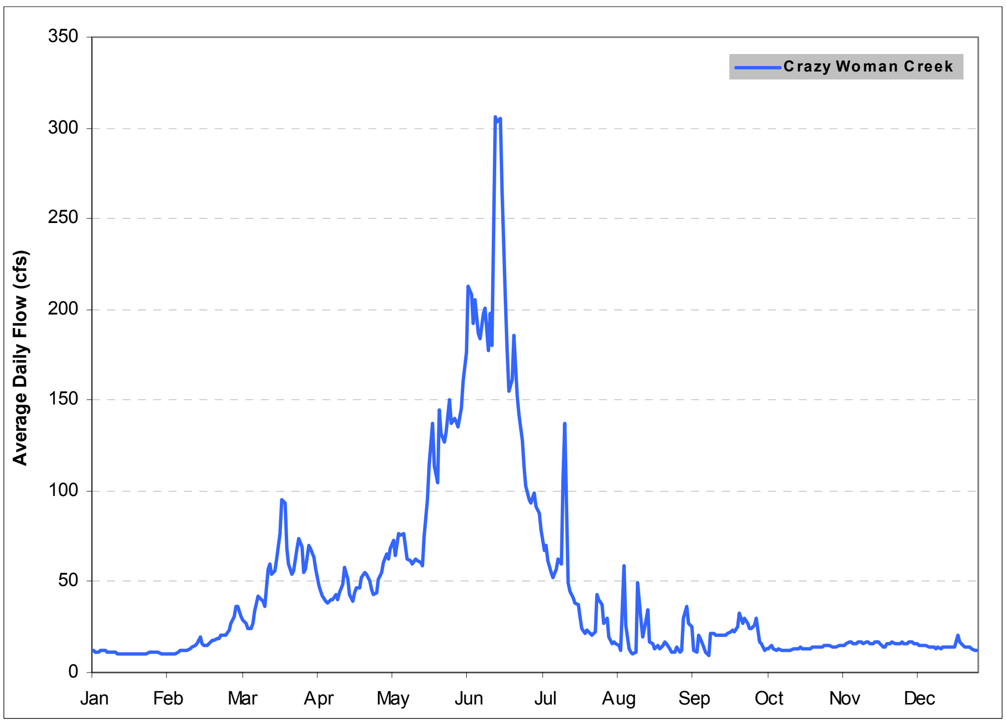

Figure 2-11. Example hydrograph of mixed flow regime, Crazy Woman Creek (1939-1981).

2.1.3.3 Stream Types

The National Hydrography Data (NHD) provided by EPA and USGS identified three major stream types in the Powder River watershed. Most of the streams in the Powder River watershed were classified as intermittent streams (Table 2-4). Intermittent streams have flow only for short periods during the course of a year, and flow events are usually initiated by rainfall. Perennial streamflow was classified only in the main stem of the major rivers (Powder River, Little Powder River, Clear Creek, Crazy Woman Creek and in the mountainous region along the southwest border of the Powder River watershed (Figure 2-12). Mountain streams of varying sizes have perennial flow due to snowmelt and precipitation, while streams located in the plains region are generally intermittent and flow after local rainstorms. Most of the canals, ditches, and pipelines are concentrated along the foothills in the Clear Creek subwatershed. This is most likely to take advantage of snowmelt runoff for irrigated crop production located near the foothills of the Clear Creek watershed.

Table 2-4. Summary of stream type in the Powder River watershed.

Stream Type	Stream Length (m)	Percent
Canal/Ditch/Pipeline	400,805	1.5
Intermittent Stream	23,374,777	86.7
Perennial Stream	3,190,877	11.8
Total	26,966,459	100.0

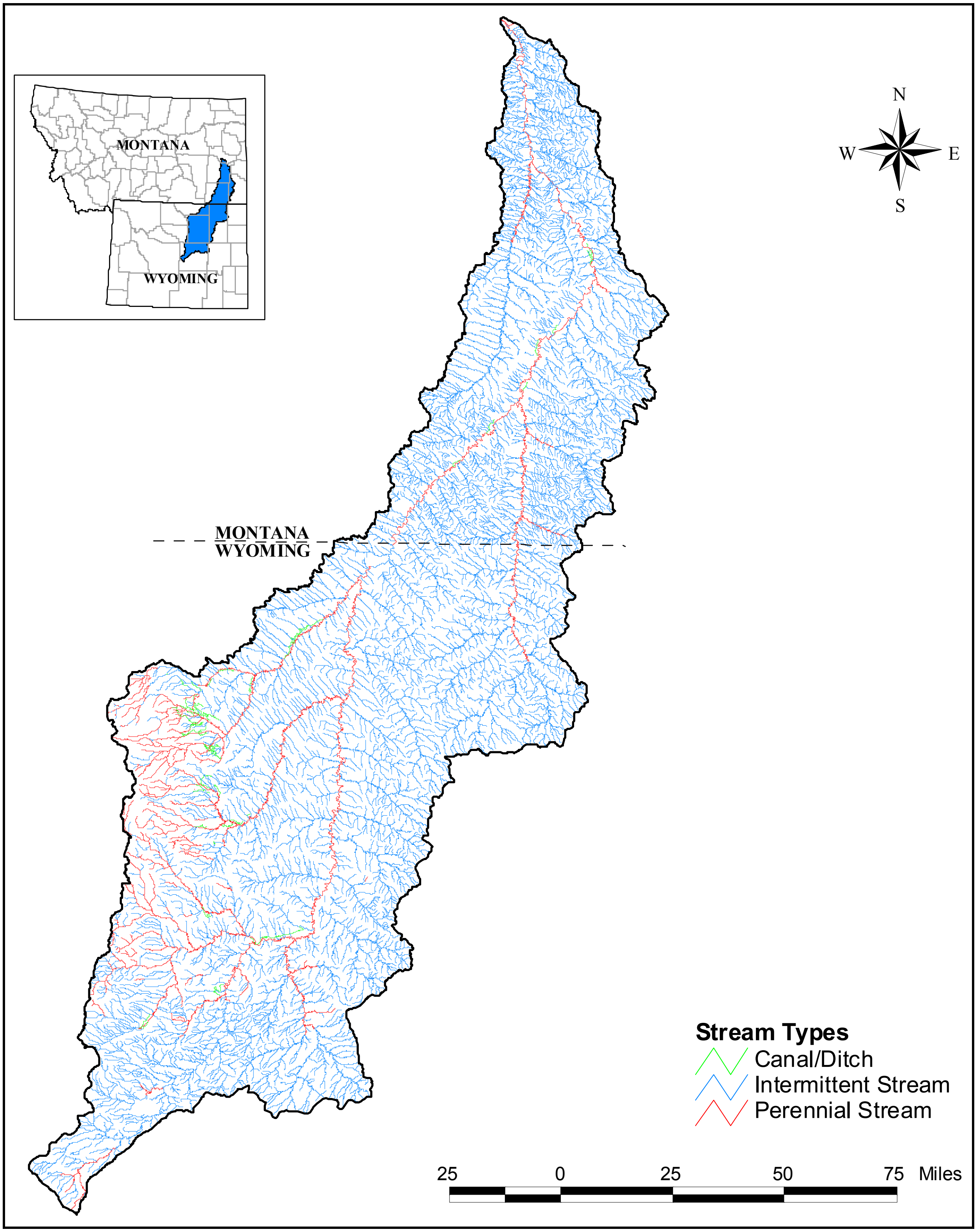

Figure 2-12. Stream types in the Powder River watershed.

2.1.3.4 Irrigation Practices

Agricultural operations in the Powder River watershed are heavily dependent on irrigation. In early 2002, DEQ and the Tongue River Water Users (TRWU) sent surveys to landowners in the watershed to obtain better information on irrigation practices. The format of the DEQ and TRWU's surveys was similar but not exactly the same, making it difficult to tabulate the results. The discussion below summarizes some of the key findings. The surveys indicate that close to 90 percent of respondents irrigate from these rivers or their tributaries. Most irrigate less than 50 acres of land but some irrigate as many as 9,400 acres. The average land area that is irrigated is 163 acres. Flood irrigation is the most common form of applying the water but sprinkler and spreader dikes are also employed.

Most survey respondents apply water once a week to gardens and lawns. Crops such as alfalfa and small grains are usually watered every 2 weeks. Table 2-5 summarizes the vegetation that is irrigated.

Table 2-5. Plants most often reported as being irrigated (organized according to category of plant and sensitivity to salt).

	Sensitivity to Salt		
Category	**Highly Sensitive**	**Moderately Sensitive**	**Somewhat Tolerant**
Field crops and forage	red clover, field beans, white dutch clover	alfalfa, brome grass, orchard grass	barley, sugar beets
Vegetables	cucumber, carrots, radish	tomatoes, bell pepper, sweet corn	beets, asparagus, spinach
Fruit crops	apple, crab apple (decorative), strawberry	cantaloupes, grapes	
Deciduous trees	mountain ash, dogwood, silver maple	green ash, american elm	cottonwood, russian olive, chokecherry
Conifer trees		blue spruce, ponderosa pine	

Almost 40 percent of the landowners that responded to the surveys reported that they have experienced crop yield problems due to existing water quality. Slightly more than half of the respondents reported having soil salinization problems.

Assessment of water right information provides another means of determining appropriation and beneficial uses of water in the Powder River watershed. Water right information acquired from the Montana Department of Natural Resources and Conservation (DNRC) demonstrates that most water for water rights is obtained from surface water diversions (Table 2-6). In all, more than 300,000 acre-feet/year of water per year of water rights are allowed in the Montana portion of the Powder River watershed. However, this is the maximum amount of water that can potentially be used throughout the watershed per year, and it does not necessarily reflect water use.

Table 2-6. Major Powder River water sources in Montana.

Water Source	Volume (acre-feet/year)	Percent Volume
Surface Diversions	243,857	79.9
Reservoirs	40,818	13.4
Wells	20,553	6.7
Total	305,228	100.0

2.1.4 Groundwater

A shallow aquifer system underlies the Powder River watershed and is composed of five hydrogeologic units located above a relatively regionally persistent and highly impermeable lithologic unit called the Upper Cretaceous Bearpaw Shale (Lewis and Hotchkiss, 1981). The uppermost hydrogeologic unit in the shallow aquifer system is the Wasatch-Tongue River aquifer, an extensive aquifer that is up to 1,190 meters thick and is exposed at the land surface throughout most of the watershed (Lewis and Hotchkiss, 1981).

Underlying the Wasatch-Tongue aquifer and extending over much of the watershed is the Lebo confining layer. This confining layer is up to 920 meters thick and generally correlates with the Lebo Shale Member of the Fort Union Formation (Lewis and Hotchkiss, 1981). Underlying the Lebo confining layer, except near outcrop areas, is the Tullock aquifer. The Tullock aquifer is up to 600 meters thick and is considered an aquifer in most of the watershed (Lewis and Hotchkiss, 1981). The Tullock aquifer is confined by the Upper Hell Creek layer, which underlies much of the watershed. Groundwater may be a potential source of pollutants in the Powder River watershed, and more information regarding the impact of groundwater on surface water beneficial uses will be presented in the Source Assessment section of the TMDL.

2.1.5 Topography

Figure 2-13 displays the general topography within the Powder River watershed, and a shaded relief map of the watershed is presented in Figure 2-14. As seen in Figure 2-13, elevations generally range from around 12,795 feet above MSL in the southwestern portion of the watershed to 2,184 feet in the northern portion of the watershed.

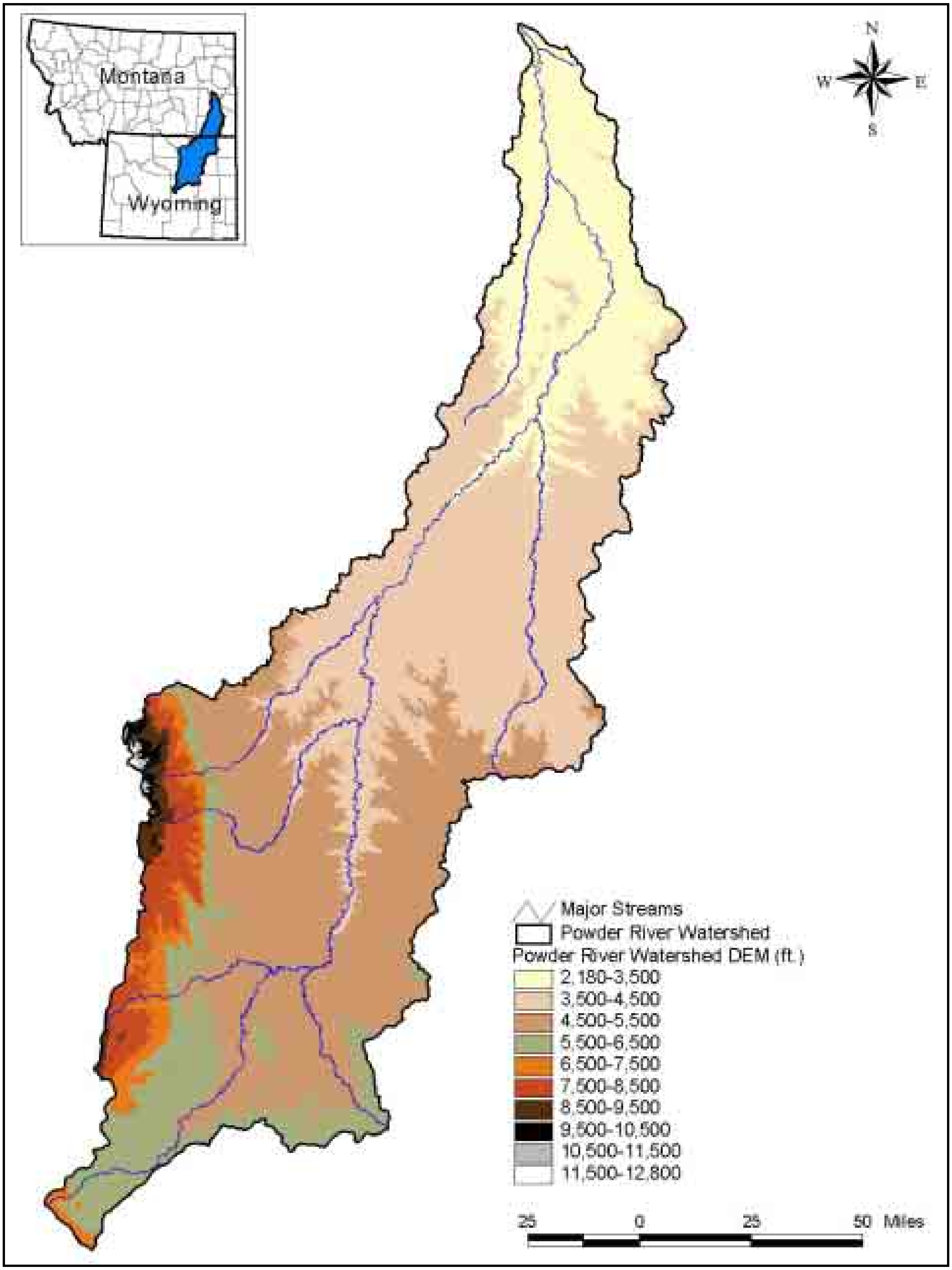

Figure 2-13. Elevation in the Powder River watershed.

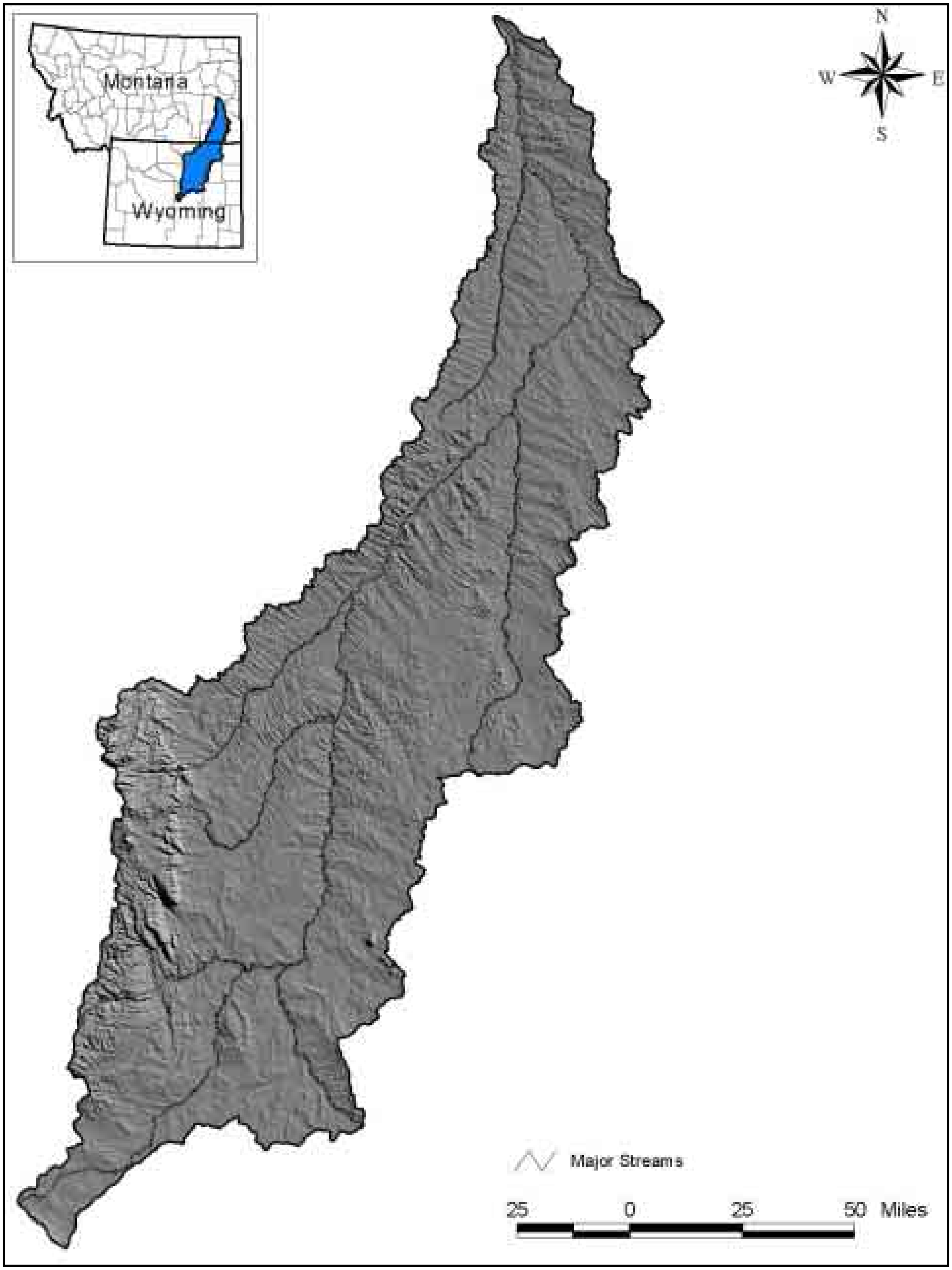

Figure 2-14. Shaded relief for the Powder River watershed.

2.1.6 Major Land Resource Areas

The USDA has determined major land resource areas (MLRAs) within the United States (USDA, 1965). The MLRAs are large area land resource units geographically associated according to the dominant physical characteristics of topography, climate, hydrology, soils, land use, and potential natural vegetation. MLRAs have been used in statewide agricultural planning and have value in interstate, regional, and national planning. A complete listing and definition of the MLRAs located in the Powder River watershed is given in Appendix A. The distribution of MLRAs in the Powder River watershed is shown in Figure 2-15, and is summarized in Table 2-7. Figure 2-15 and Table 2-7 show that nearly 76 percent of the Powder River watershed is classified as northern rolling high plains. A smaller area on the southwestern fringe of the watershed is classified as northern Rocky Mountains and foothills.

Table 2-7. MLRAs of the Powder River watershed.

MLRA Classification	Area (acres)	Area (miles^2)	Percentage
Central Desertic Basins, Mountains, and Plateaus	316,409	494.4	3.7
Northern Rocky Mountain Foothills	741,091	1,158.0	8.6
Northern Rocky Mountains	119,512	186.7	1.4
Northern Rolling High Plains, Northern Part	2,098,799	3,279.4	24.5
Northern Rolling High Plains, Southern Part	4,399,707	6,874.5	51.3
Pierre Shale Plains and Badlands	88,674	138.6	1.0
Pierre Shale Plains, Northern Part	550,873	860.7	6.4
Semiarid Rocky Mountains	262,978	410.9	3.1
Total Area	8,578,043	13,403.2	100.0

2.1.7 Land Use and Land Cover

General land use and land cover data for the Powder River watershed was extracted from the Multi-Resolution Land Characterization (MRLC) database for the states of Montana and Wyoming (MRLC, 1992) and is shown in Figure 2-16. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data known to be available. Each 100-foot by 100-foot pixel contained within the satellite image is classified according to its reflective characteristics. A complete listing and definition of the MRLC land cover categories is given in Appendix B. Table 2-8 summarizes land cover in the Powder River watershed and shows that grassland is the dominant land cover, comprising approximately 58.9 percent of the total land cover. Shrubland and evergreen forest comprise 28.8 percent and 6.2 percent, respectively. Other important cover types include small grains (1.4 percent), fallow land (1.4 percent), and pasture/hay (1.2 percent). All other individual land cover types comprise less than one percent of the total watershed area.

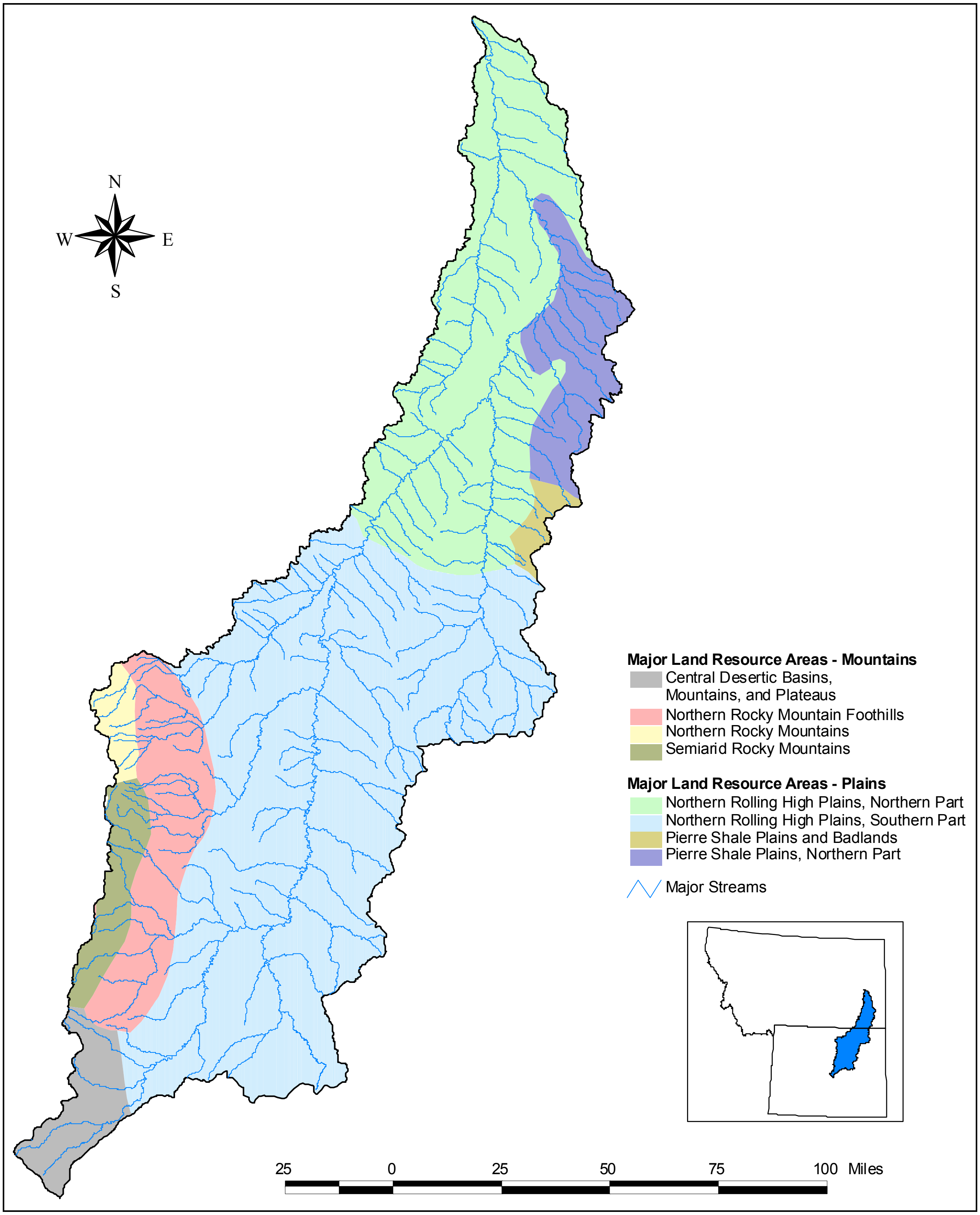

Figure 2-15. MLRAs in the Powder River watershed.

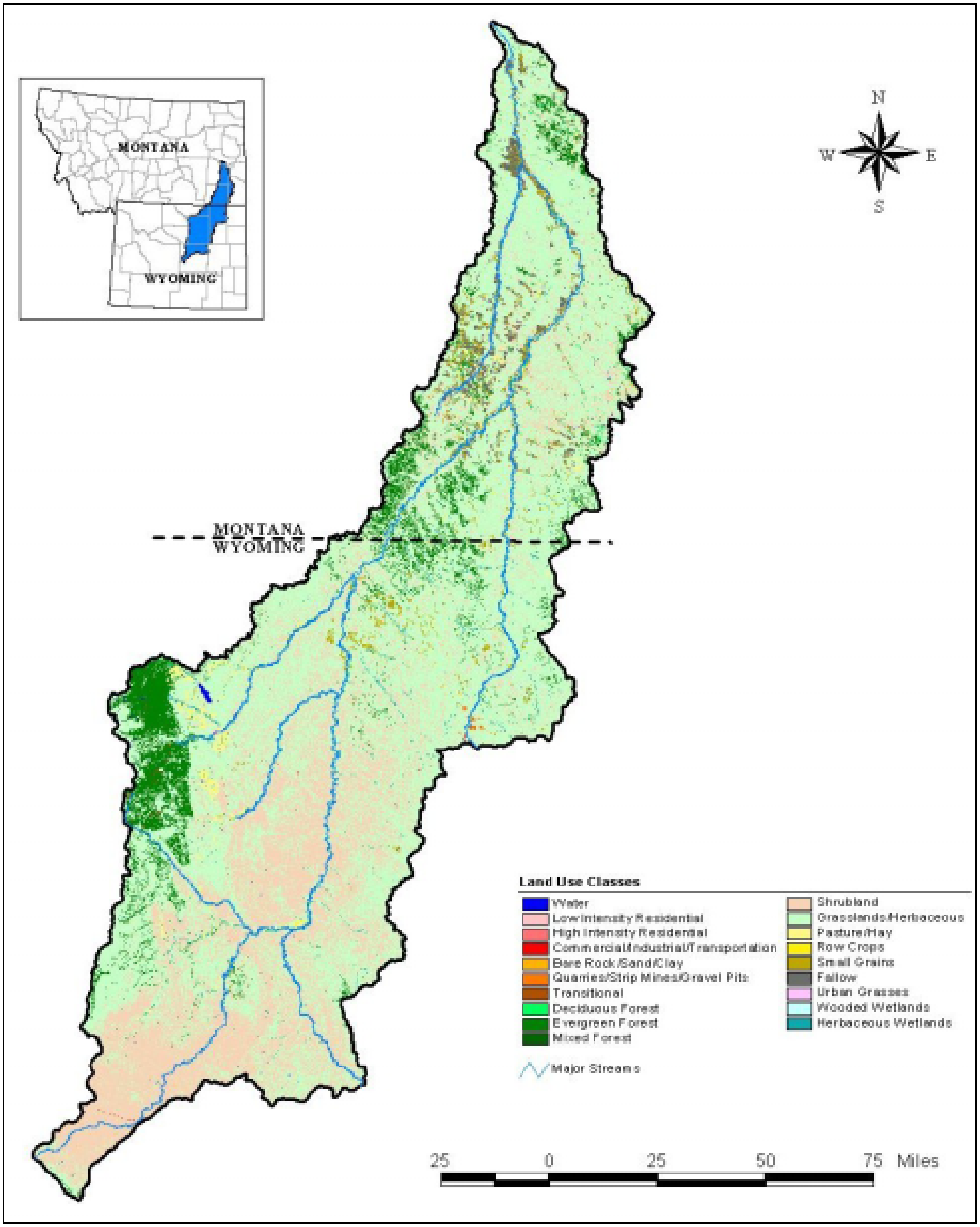

Figure 2-16. Land Use and Land Cover in the Powder River watershed.

Table 2-8. Land use and land cover in the Powder River watershed.

Land Use/Land Cover	Area		Percent of Watershed
	Acres	Square Miles	
Grasslands/Herbaceous	5,058,945	7,904.6	58.95
Shrubland	2,473,869	3,865.4	28.83
Evergreen Forest	535,141	836.2	6.24
Small Grains	120,361	188.1	1.40
Fallow	116,265	181.7	1.35
Pasture/Hay	100,576	157.1	1.17
Herbaceous Wetlands	66,129	103.3	0.77
Deciduous Forest	37,954	59.3	0.44
Wooded Wetlands	26,625	41.6	0.31
Water	14,185	22.2	0.17
Row Crops	10,319	16.1	0.12
Bare Rocks/Sand/Clay	5,342	8.3	0.06
Transitional	4,473	7.0	0.05
Mixed Forest	3,287	5.1	0.04
Quarries/Strip Mines/Gravel Pits	3,224	5.0	0.04
Commercial/Industrial/Transportation	2,628	4.1	0.03
Low-Intensity Residential	1,412	2.2	0.02
Urban Grasses	426	0.7	<0.01
High-Intensity Residential	144	0.2	<0.01
Total	8,582,267	13,409.8	100.00

2.1.8 Vegetative Cover

Vegetative data were gathered from Gap Analysis Projects (GAP) completed for the states of Wyoming and Montana. The GAP is a nationwide program conducted under the guidance of the USGS for the purpose of assessing the extent of conservation of native plant and animal species. Since an important part of the analysis is the identification of habitat, detailed vegetative spatial data are usually available for states that have completed their analyses. Like the MRLC data, the spatial databases for Wyoming and Montana were derived from satellite imagery taken during the early 1990s. However, the vegetative classification is much more detailed than that of the MRLC. GAP data include vegetative species such as ponderosa pine, rather than general land cover classes like evergreen forest. Furthermore, the vegetation classifications differ between the Wyoming and Montana GAP databases. Therefore, the vegetative cover provided by the GAP data for the Powder River watershed are shown for the states of Montana and Wyoming in Figures 2-17 and 2-18, respectively, and summarized according to state in Tables 2-9 and 2-10.

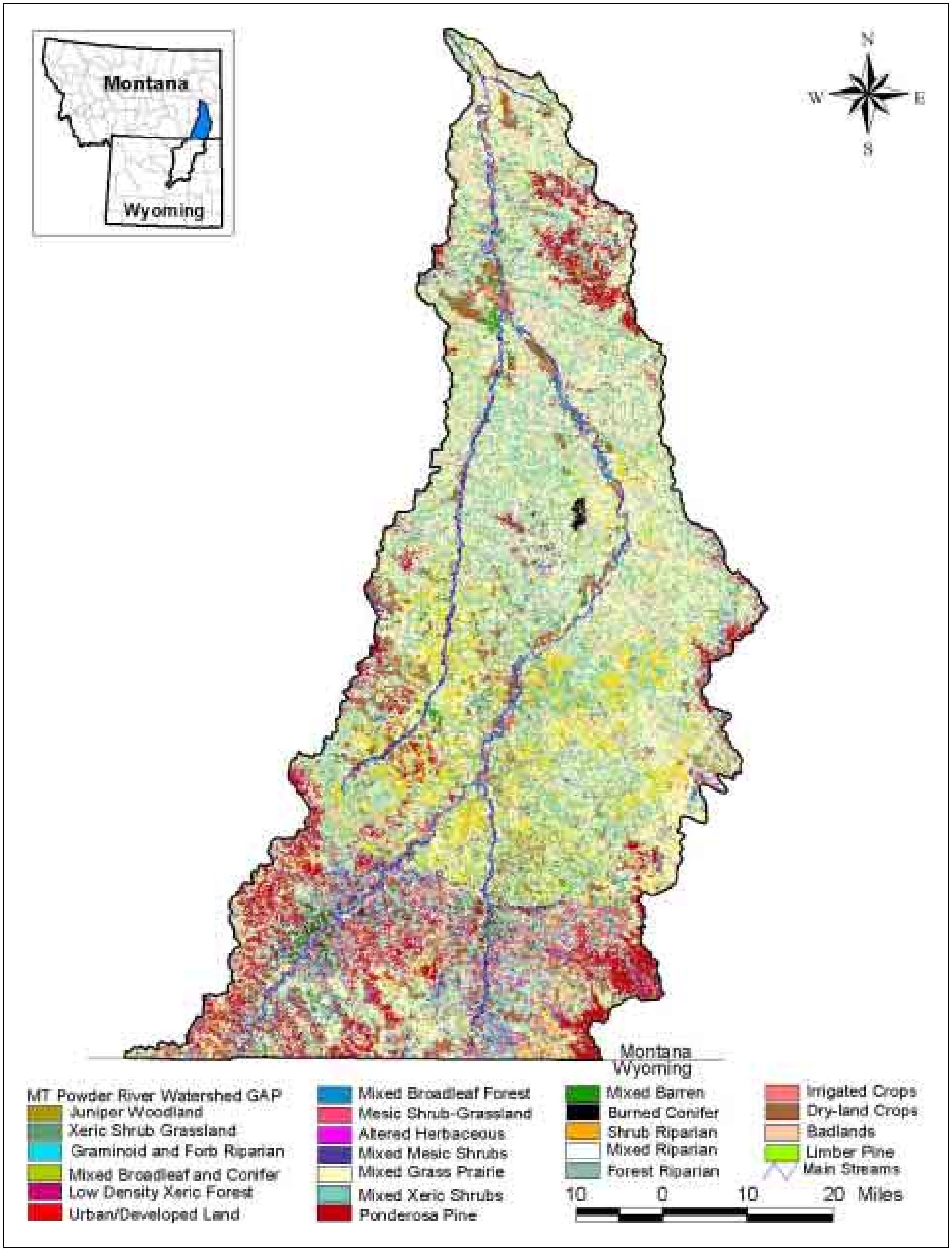

Figure 2-17. Vegetative cover in the Montana portion of the Powder River watershed.

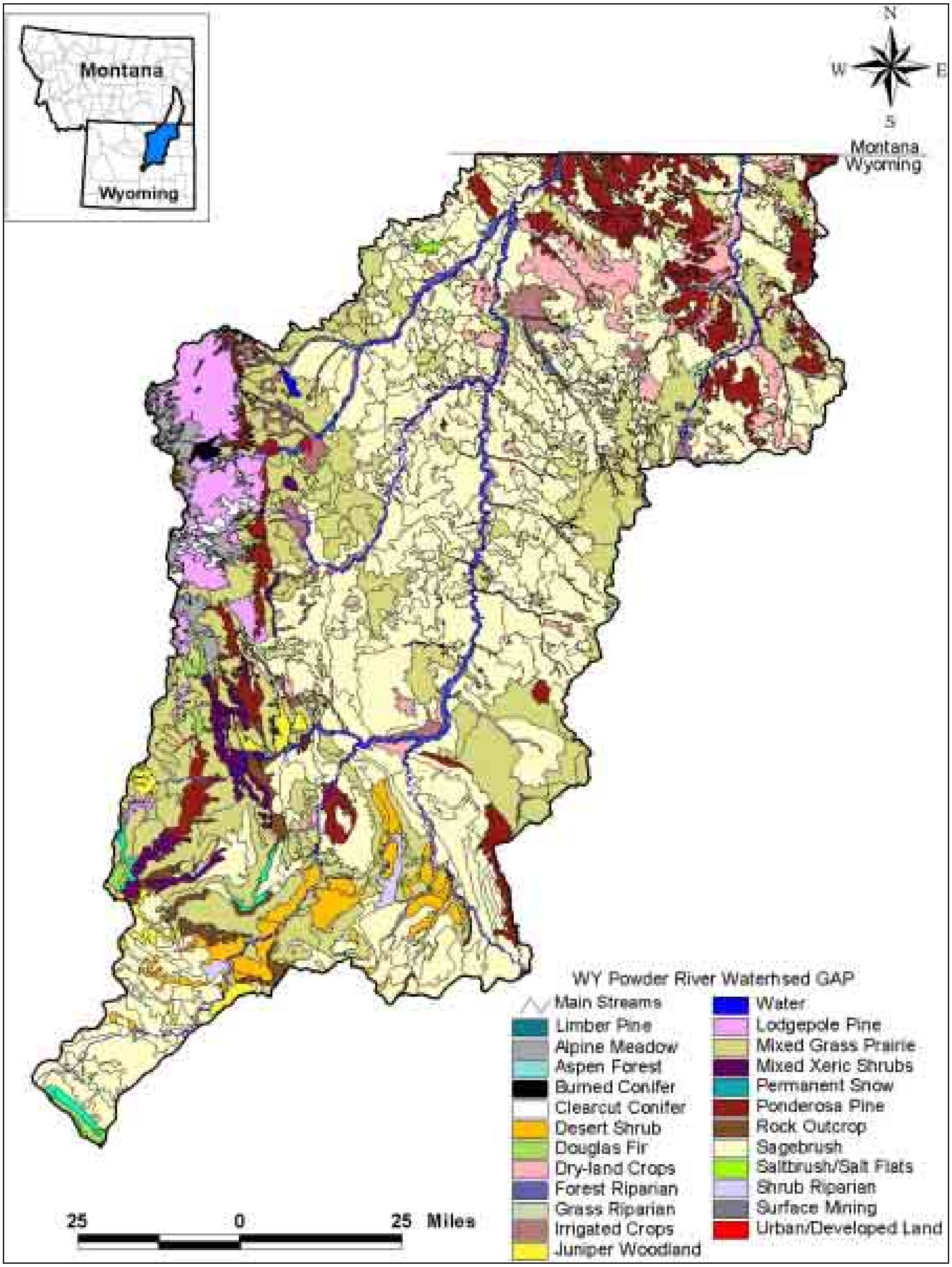

Figure 2-18. Vegetative cover in the Wyoming portion of the Powder River watershed.

Table 2-9. Vegetative cover according to GAP for the Montana portion of the Powder River watershed.

Vegetative Cover	Area		Percent of Watershed
	Acres	Square Miles	
Mixed Grass Prairie	1,053,298	1,645.8	40.57
Mixed Xeric Shrubs	401,956	628.1	15.48
Sagebrush	228,679	357.3	8.81
Badlands	143,731	224.6	5.54
Ponderosa Pine	134,462	210.1	5.18
Dryland Crops	99,653	155.7	3.84
Xeric Shrub-Grassland	89,837	140.4	3.46
Mesic Shrub-Grassland	78,451	122.6	3.02
Graminoid and Forb Riparian	65,436	102.2	2.52
Mixed Mesic Shrubs	62,933	98.3	2.42
Low-density Xeric Forest	52,492	82.0	2.02
Shrub Riparian	33,760	52.8	1.30
Mixed Barren	26,617	41.6	1.03
Forest Riparian	25,554	39.9	0.98
Rock Outcrop	22,245	34.8	0.86
Irrigated Crops	15,120	23.6	0.58
Altered Herbaceous	12,912	20.2	0.50
Mixed Broadleaf Forest	12,568	19.6	0.48
Mixed Riparian	9,986	15.6	0.38
Mixed Broadleaf and Conifer	7,826	12.2	0.30
Water	5,806	9.1	0.22
Juniper Woodland	5,192	8.1	0.20
Limber Pine	4,798	7.5	0.18
Burned Conifer	2,662	4.2	0.10
Urban/Developed Land	260	0.4	0.01
Total	2,596,233	4056.6	100.00

Table 2-10. Vegetative cover according to GAP for the Wyoming portion of the Powder River watershed.

Vegetative Cover	Area		Percent of Watershed
	Acres	Square Miles	
Sagebrush	2,869,752.6	4,484.0	47.97
Mixed Grass Prairie	1,432,958.8	2,239.0	23.95
Ponderosa Pine	410,401.0	641.3	6.86
Dryland Crops	252,435.0	394.4	4.22
Lodgepole Pine	200,935.2	314.0	3.36
Desert Shrub	142,970.4	223.4	2.39
Irrigated Crops	118,721.7	185.5	1.98
Forest Riparian	117,777.0	184.0	1.97
Alpine Meadow	77,043.5	120.4	1.29
Mixed Xeric Shrubs	69,541.7	108.7	1.16
Juniper Woodland	55,727.0	87.1	0.93
Rock Outcrop	53,711.5	83.9	0.90
Shrub Riparian	46,852.2	73.2	0.78
Grass Riparian	31,556.4	49.3	0.53
Douglas Fir	28,091.7	43.9	0.47
Clearcut Conifer	23,848.4	37.3	0.40
Whitebark Pine	22,445.3	35.1	0.38
Burned Conifer	6,679.2	10.4	0.11
Saltbrush/Salt Flats	6,431.0	10.0	0.11
Surface Mining	4,867.8	7.6	0.08
Water	4,141.2	6.5	0.07
Aspen Forest	3,158.4	4.9	0.05
Urban/Developed Land	1,965.5	3.1	0.03
Permanent Snow	544.4	0.9	0.01
Total	5,982,556.9	9347.7	100.00

Inspection of Tables 2-9 and 2-10 show that the proportions of vegetative cover types are similar in both the Montana and Wyoming portions of the Powder River watershed. The dominant vegetative cover types in the Montana portion of the watershed are mixed grass prairie, mixed xeric shrubs, and sagebrush, comprising 40.57 percent, 15.48 percent, and 8.81 percent of the total vegetative cover, respectively. Dryland crops comprise 3.84 percent of the total vegetative cover in the watershed and are primarily located on river valley floors near the Wyoming border, and along river valley floors in the lower portion of the watershed. Irrigated crops comprise 0.58 percent of the total vegetative cover and are typically located on valley floors along the major tributaries and the main stem of the Powder River.

In the Wyoming portion of the watershed, sagebrush, mixed grass prairie, and ponderosa pine are the three largest vegetative cover types, comprising 47.97 percent, 23.95 percent, and 6.86 percent respectively of the total vegetative cover in the watershed. Dryland crops represent 4.22 percent of the total vegetative cover and most of this cover type is found along river valley floors. Irrigated crops account for 1.98 percent of the total vegetative cover and are concentrated along the mountain foothills of the Clear Creek subwatershed, and on the valley floor of the main stem of the Powder River.

2.1.9 Soils

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Powder River watershed. General soils data and map unit delineations for the United States are provided as part of the State Soil Geographic (STATSGO) database. The STATSGO data set was created to provide a general understanding of soils data to be used with large-scale analyses. Small, site-specific analyses with the STATSGO data are not appropriate. GIS coverages provide accurate locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverages can be linked to a database that provides information on chemical and physical soil characteristics. Figure 2-19 shows the general map unit boundaries in the Powder River watershed, and the following sections summarize relevant chemical and physical soil data.

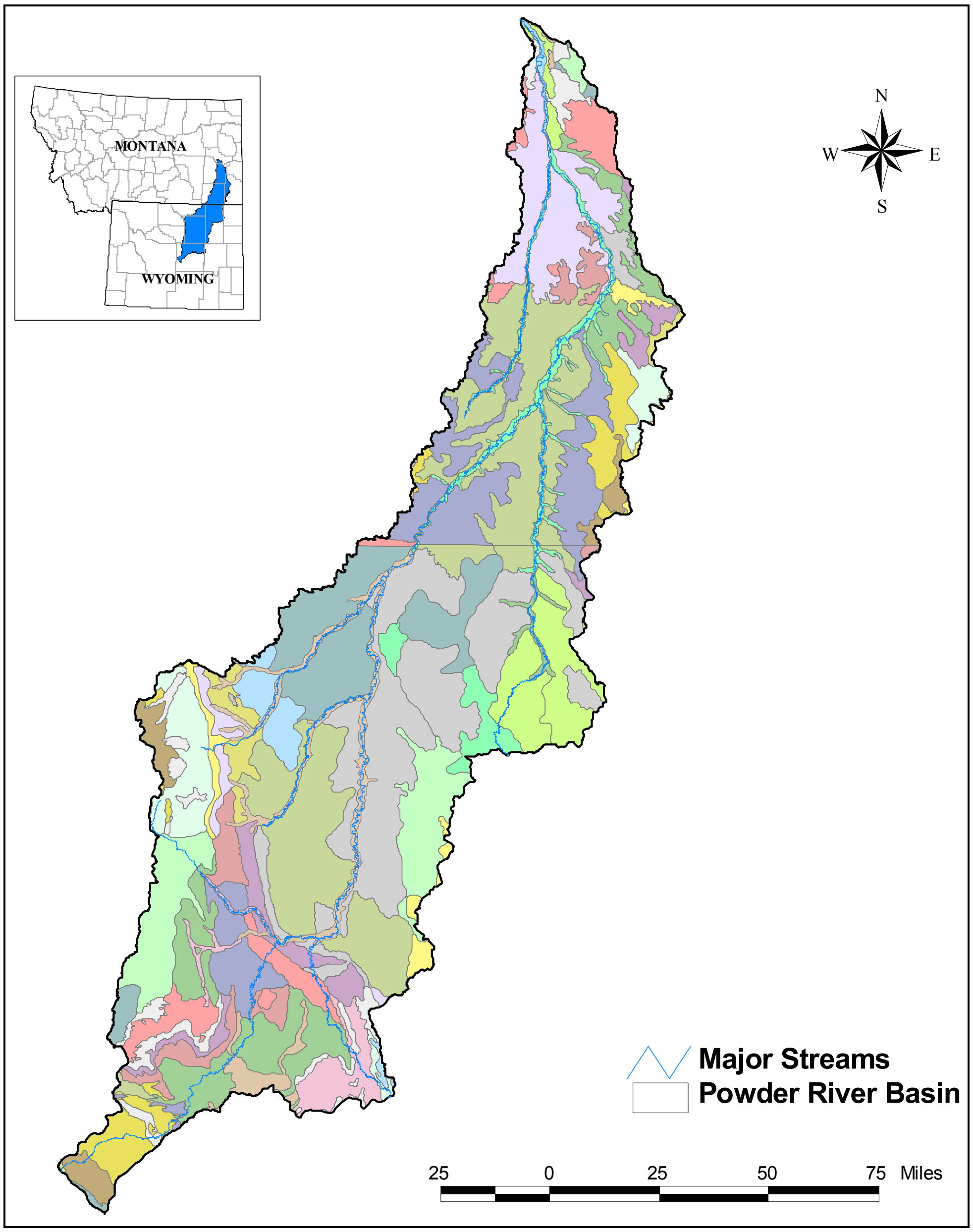

Figure 2-19. General soil units in the Powder River watershed.

2.1.9.1 Universal Soil Loss Equation (USLE) K-factor

A commonly used soil attribute is the K-factor, a component of the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and factor values may range from zero for water surfaces, to 1.00 (although in practice, maximum factor values do not generally exceed 0.67). Large K-factor values reflect greater inherent soil erodibility. The distribution of K-factor values in the Powder River watershed is shown in Figure 2-20. The figure indicates that nearly all of the soils in the watershed have K-factors ranging from 0.2 to 0.4, suggesting moderate soil erosion potential. The figure also shows that soils in the higher end of the moderate erosion susceptibility class (K-factors of 0.3 to 0.4) occur throughout much of the lower portion of the Powder River watershed.

2.1.9.2 Hydrologic Soil Groups

The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have the worst infiltration rates, while sandy soils that are well-drained have the best infiltration rates. NRCS has defined four hydrologic groups for soil, and data for the Powder River watershed were obtained from STATSGO (Table 2-11) (NRCS, 2001a). Downloaded data were summarized based on the major hydrologic group in the surface layers of the map unit and are displayed in Figure 2-21.

The majority of soils in the Powder River watershed are D soils and have poor infiltration when saturated. This is most likely because of the high clay content of many of the soils in the region. Only a small portion of soils in the lower Powder River watershed has high infiltration rates. These are the alluvial soils along the Powder River near Locate, Montana. Other alluvial soils found along the major streams were classified as B soils, except for the alluvial area near the confluence of Mizpah Creek and the Powder River.

Table 2-11. Hydrologic soil groups.

Hydrologic Soil Groups	Description
A	Soils with high infiltrations rates. Usually deep, well-drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well-drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

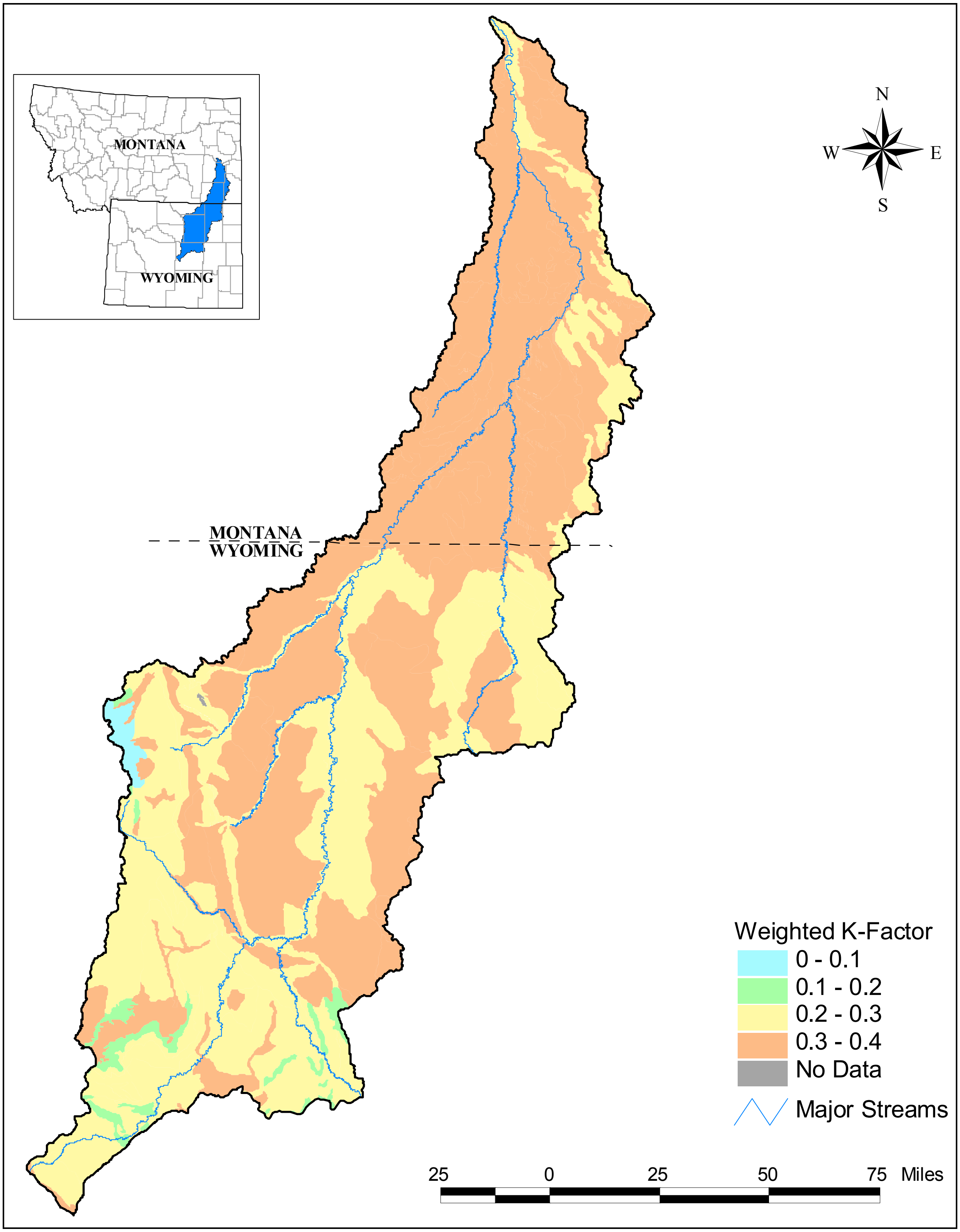

Figure 2-20. Distribution of the USLE K-factor.

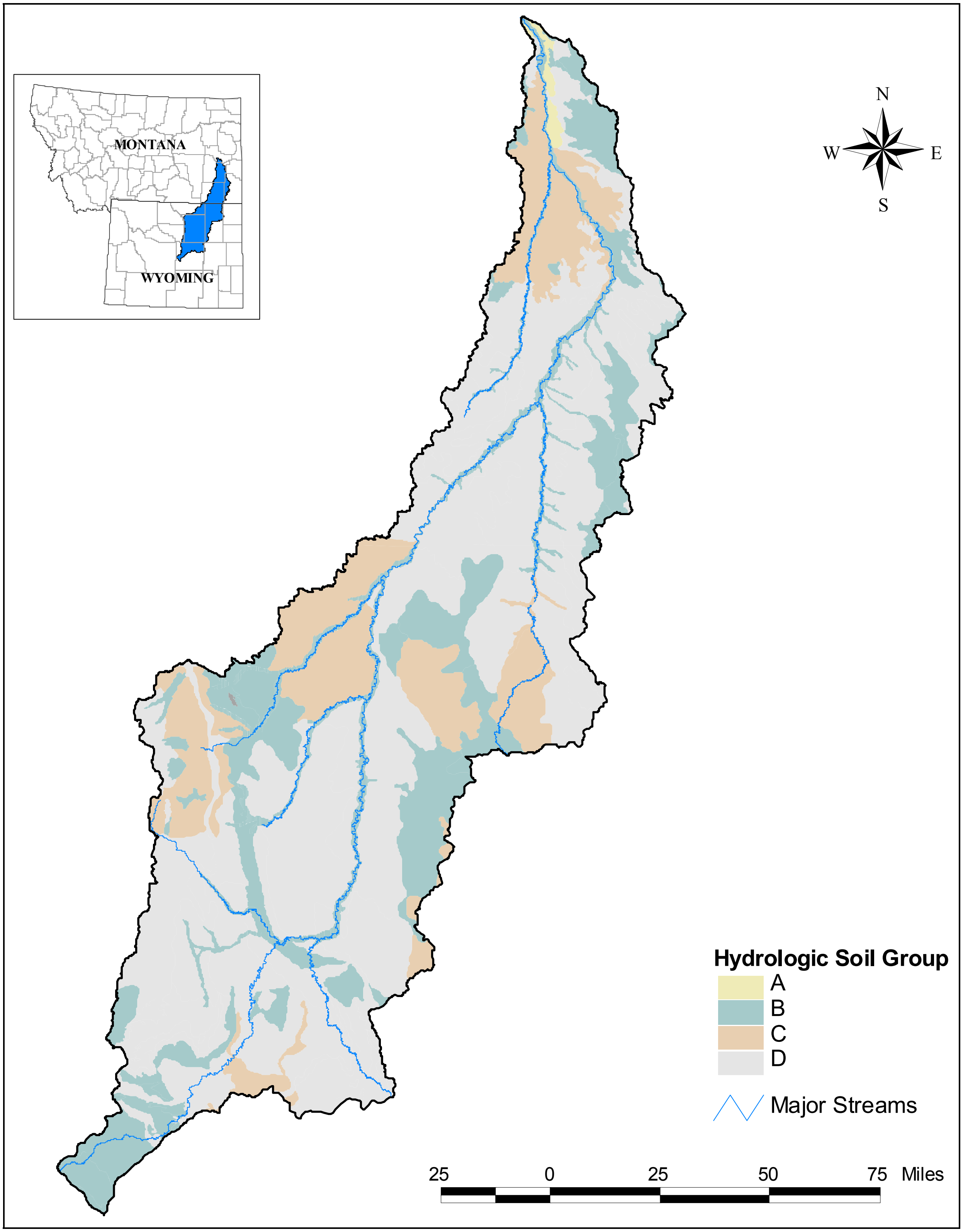

Figure 2-21. Distribution of hydrologic soil groups.

2.1.9.3 Permeability

Permeability is defined as the rate at which water moves through a soil. It is measured in inches per hour and varies with soil texture, structure, and pore size. Soil uses, such as agriculture, septic systems, and construction, can be limited when permeability is too slow. Clays are usually the least permeable soils and sands and gravels the most permeable. NRCS has provided the minimum and maximum ranges for permeability in the Powder River watershed in the STATSGO database. For the purpose of this analysis, permeabilities are reported for the surface layers of the dominant soil type in the STATSGO map units.

Figure 2-22 shows that minimum permeabilities in the Powder River watershed range from very slow to very rapid. Soils with the lowest permeabilities were found in the Rocky Mountains near the Middle Fork Powder River and in the headwater regions of the Powder River near the South Fork Powder River and Salt Creek. Most of the soils in the plains region of the Powder River Basin had moderate or moderately slow minimum permeabilities, and range from moderately slow to moderately rapid.

2.1.9.4 Salinity

Salts are naturally occurring in the Powder River watershed due to bedrock materials that are easily weathered. These salts are found in varying concentrations in soils and waters throughout the watershed. In arid regions, salts also accumulate in soils due to evaporation that tends to concentrate salts in the upper soil layers. The term salts refers to several different anions and cations that may or may not be present in solution. The most common salts are calcium, magnesium, sodium, chloride, sulfate, and bicarbonate and they are usually measured in terms of electrical conductivity (EC) or total dissolved solids (TDS). NRCS classifies saline as having an EC greater than 4,000 µS/cm. High salt concentrations in soil can limit the amount of plant-available water and cause plant mortality, but this varies depending on the type of plant, soil, root depth, and salt depth.

Figure 2-23 shows the distribution of soil salt concentrations in the Powder River watershed. Data were obtained from the STATSGO database and they represent the maximum salinity reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-23 is meant as a general representation of salinity throughout the watershed. Most of the Powder River watershed soils had EC between 2,000 and 8,000 µS/cm. Because of the moderate to high salt concentrations found throughout the watershed, many of the soils are naturally limiting to plant growth. The area of lowest salinity was found in the Bighorn Mountains, while the highest salt concentrations were located along the main stem of the Powder River, Little Powder River, and Mizpah Creek.

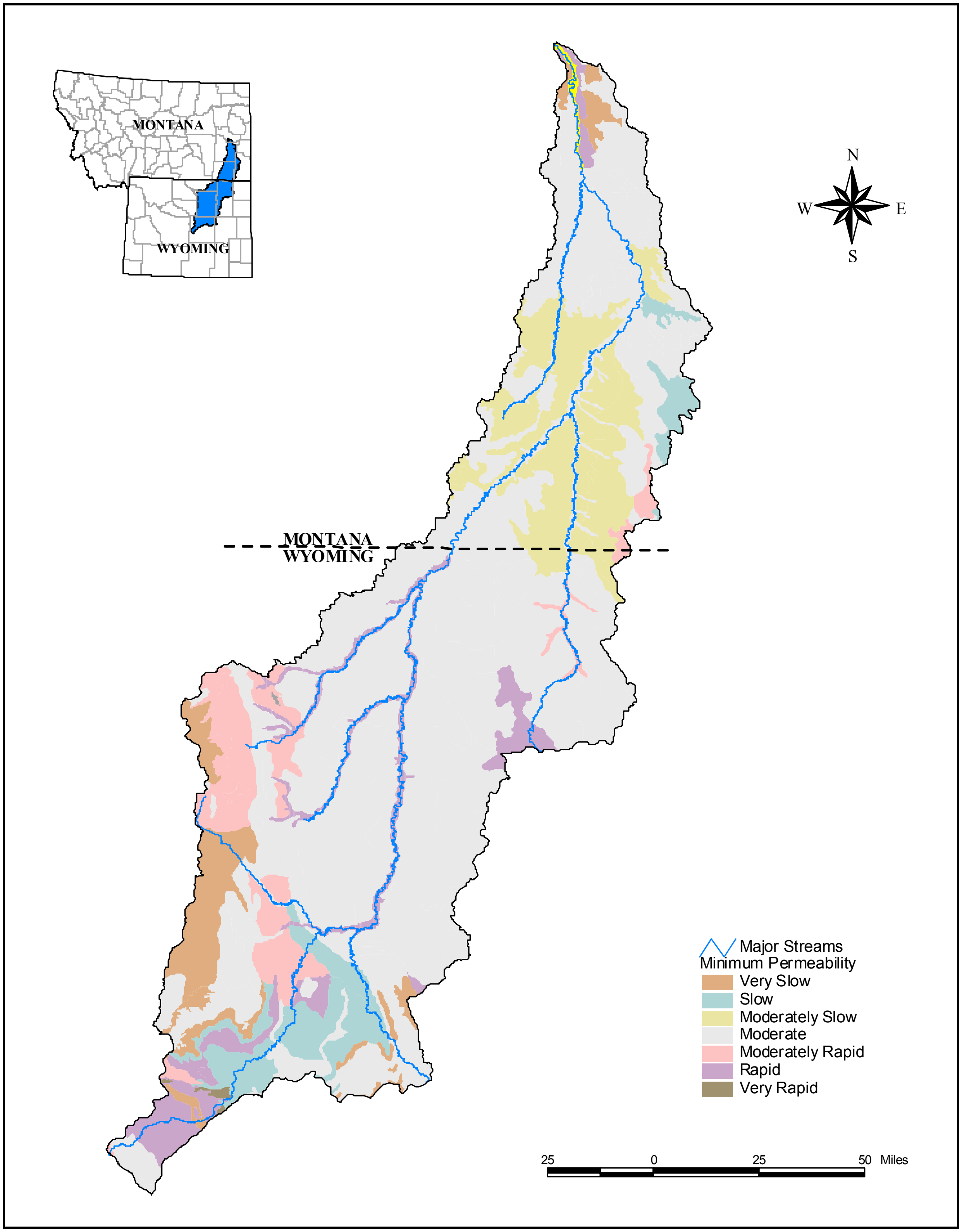

Figure 2-22. Distribution of minimum soil permeabilities.

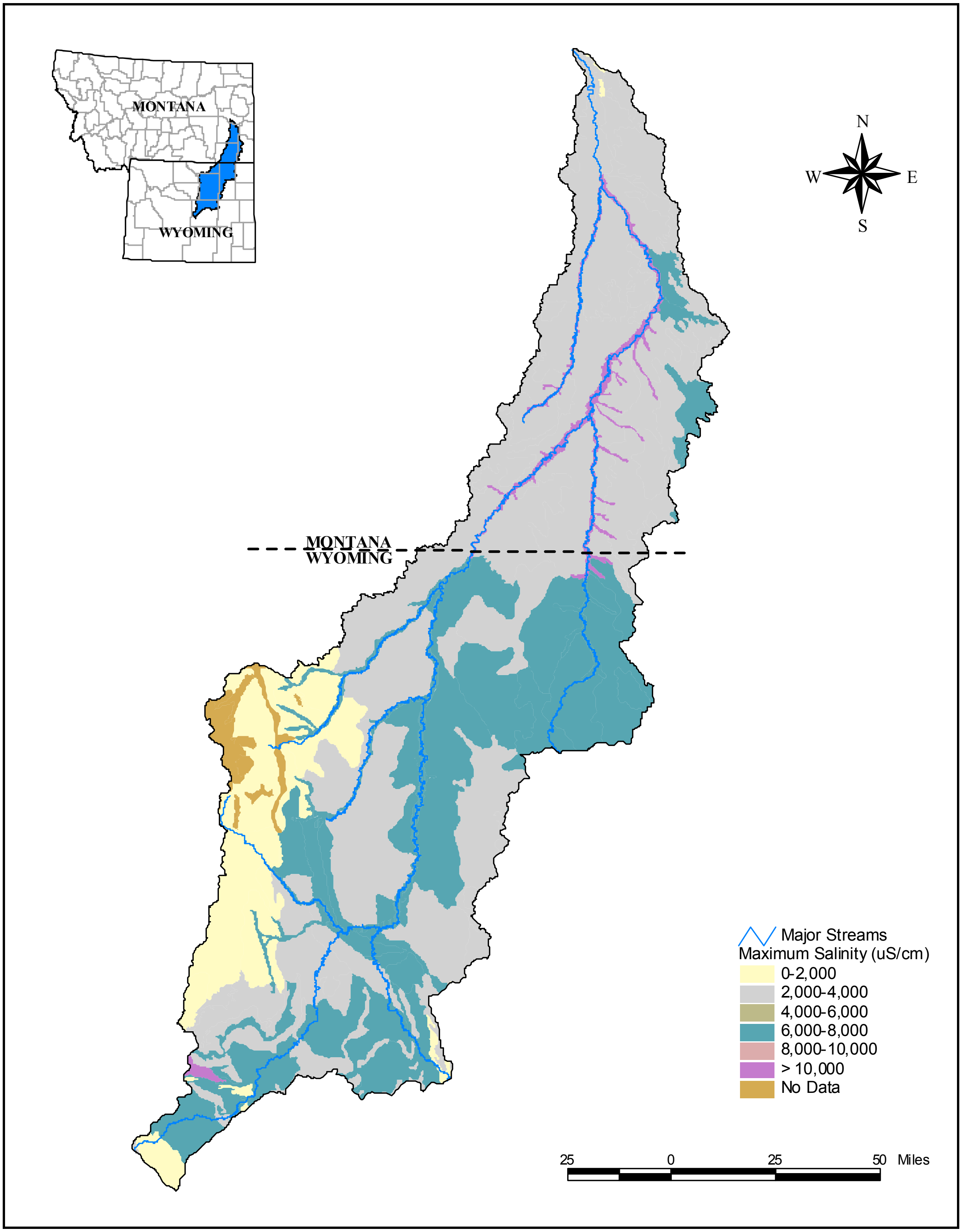

Figure 2-23. Distribution of soil salt concentrations in the Powder River watershed.

2.1.9.5 Sodium Adsorption Ratio

Sodium salts are naturally occurring in the Powder River watershed due to sodium-rich bedrock in certain areas. These salts make their way into soils through weathering processes and water transport. Due to evaporation, sodium then tends to accumulate in the soil surface layers and can have adverse effects on plants and soils. High sodium concentrations can disperse clay soils, changing the soil structure and rendering the soil hard and resistant to water and aeration. Sodium is also toxic to plants at elevated concentrations and raises the pH of a soil, which can also be toxic to plants.

Calcium and magnesium in the soil solution help to mitigate the effects of high sodium concentrations on soil structure. Because of this, a sodium adsorption ratio (SAR) is often used to determine the potential for sodium-caused impairment. SAR is the ratio of sodium to calcium plus magnesium in water. The units for the ions are milliequivalents per liter (meq/L). The exact ratio is shown below:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

Figure 2-24 shows the distribution of soil SAR values in the Powder River watershed. Data were obtained from the STATSGO database and they represent the maximum SAR reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-24 is meant as a general representation of the SAR throughout the watershed. The highest ratios are located in the headwaters of the Powder River along the main stem. SAR tends to be higher in the floodplains than in the upland areas.

2.1.9.6 Clay Content

The clay content of a soil affects the soil in many ways. Structure, texture, water-holding capacity, and the mineral content of clay all help define the use of soil. In the Powder River watershed, clay content of the soil ranges from 10 to 70 percent (see Figure 2-25). Data for Figure 2-25 were obtained from the STATSGO database and they represent the maximum clay content reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-25 is meant as a general representation of the clay content throughout the watershed.

Clay content is an important soil characteristic in the Powder River watershed because soils with high amounts of clay are more susceptible to the effects of high sodium concentrations. This suggests that the lower Powder River and Mizpah Creek watershed soils are the most at risk if sodium concentrations were to increase in this area. Also, most of the soils in the Powder River watershed have high clay content (40 to 60 percent) and could be susceptible to increased sodium concentrations.

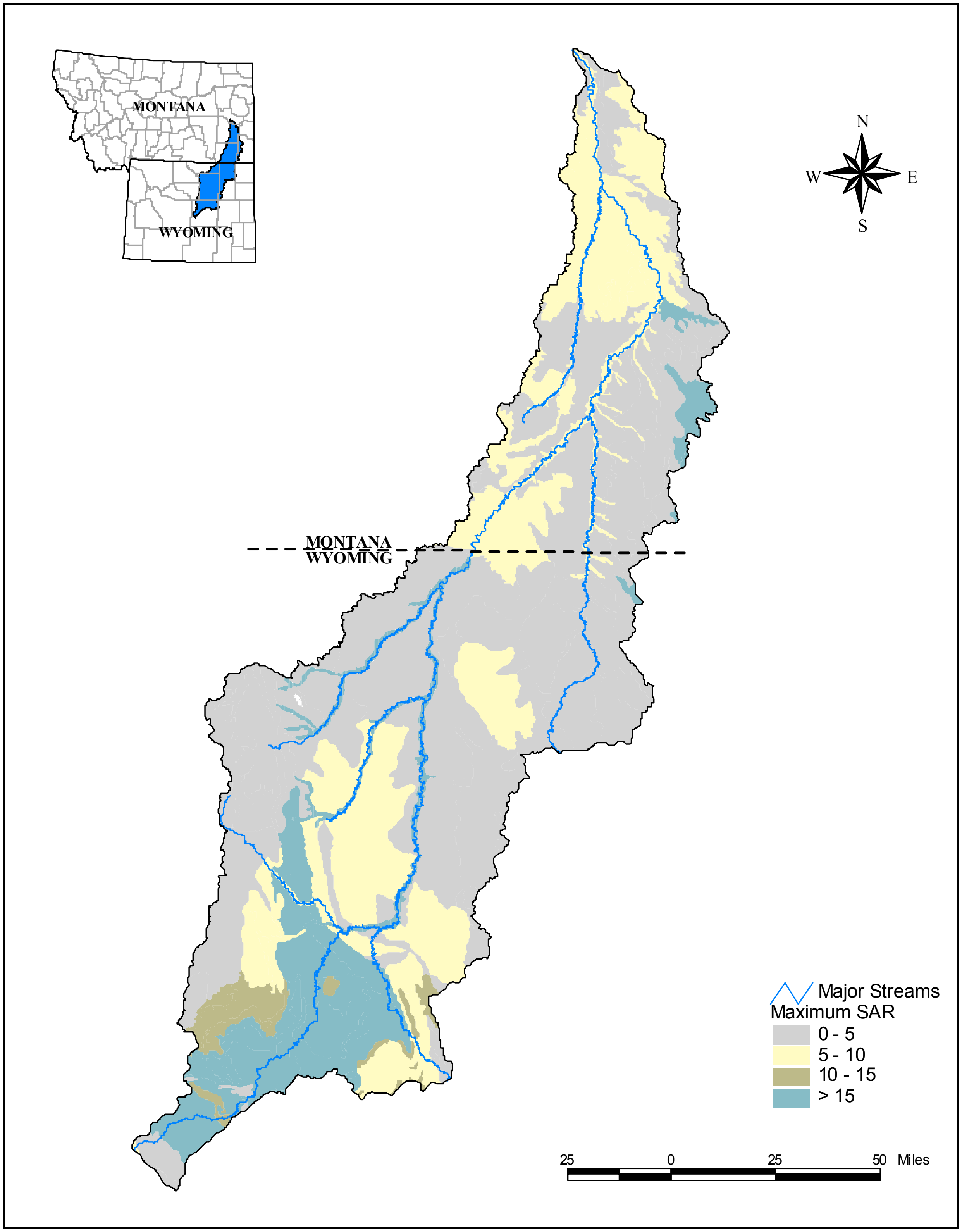

Figure 2-24. SAR in the Powder River watershed.

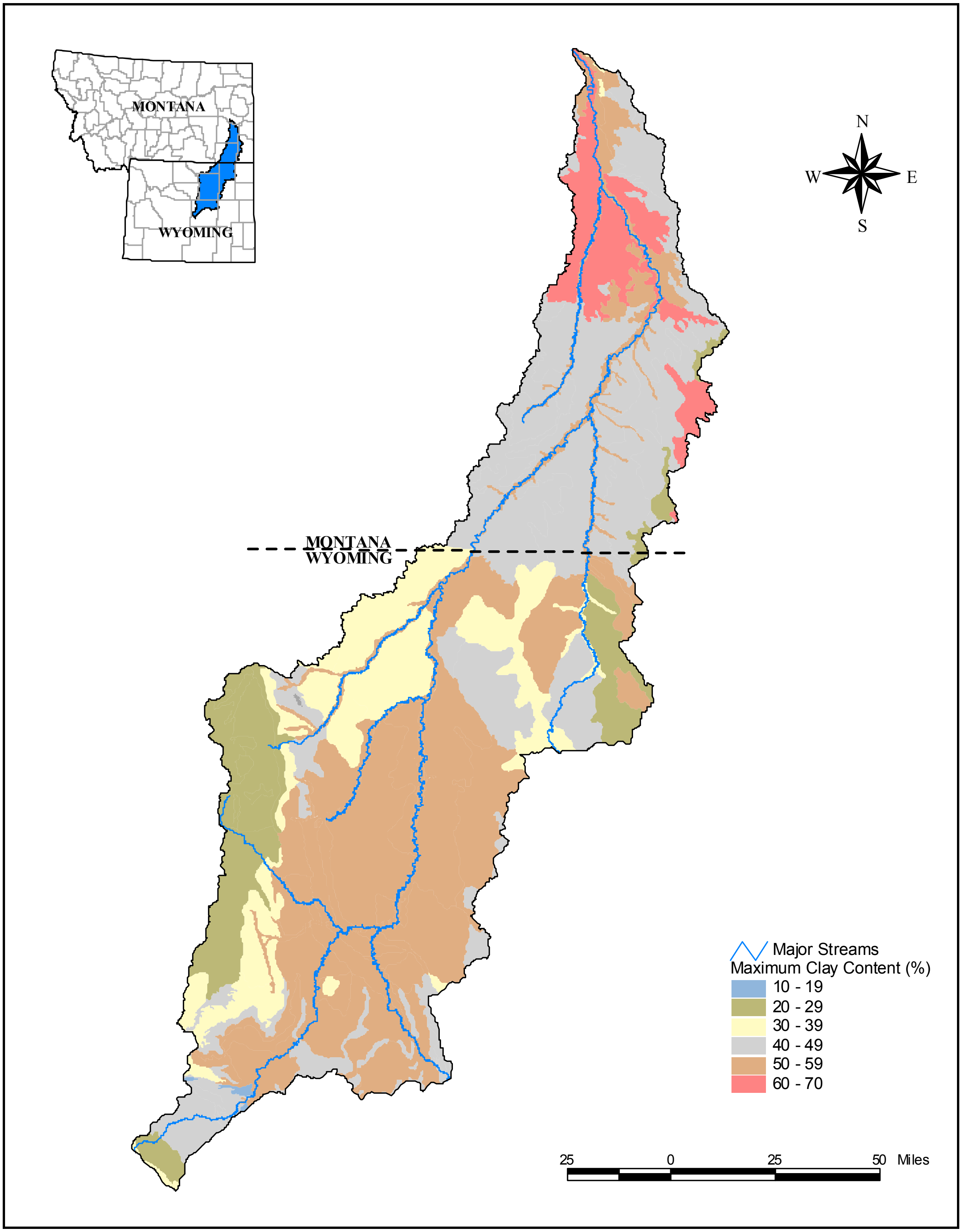

Figure 2-25. Soil clay content in the Powder River watershed.

2.1.10 Riparian characteristics

2.1.10.1 Vegetation

Vegetative characteristics within the riparian corridor of the Powder River watershed were examined by creating a 492-foot buffer (150-meter) on either side of the main stem and major tributaries of the Powder River in ArcView GIS. This buffer was then overlain on the GAP vegetative cover layers for both the Montana and Wyoming portions of the watershed, and the vegetative classes lying within the buffer were extracted. Since the vegetative classifications differ between the Montana and Wyoming GAP data, the riparian vegetative characteristics are given separately for the buffered areas in each state. Table 2-12 gives the riparian vegetation characteristics for the portion of the watershed in Montana, and Table 2-13 lists the riparian vegetation characteristics for the Wyoming portion of the watershed.

The buffering technique described above identified 198,203 riparian acres in the Montana portion of the Powder River watershed (see Table 2-12). Of this area, 59,714 acres (30.13 percent) are in mixed grass prairie vegetation, 27,886 acres (14.07 percent) consist of graminoid and forbs,[1] and another 19,421 acres (9.8 percent) are in mixed xeric shrub vegetation. Additionally, riparian shrub, riparian forest, and dry-land crops comprise 14,954 acres (7.54 percent), 14,103 acres (7.12 percent), and 11,349 acres (5.73 percent), respectively, within the riparian corridor.

The NRCS Phase II Stream Corridor Assessment found that plant communities along the Powder River were complex (NRCS, 2002). Vegetation was different along the stream channel and associated river terraces found near the main stem of the river. Terraces were generally composed of eastern cottonwood and western snowberry. Prairie cordgrass was found in the channel with coyote willow and cottonwood found on the pointbars. Where cottonwood communities were reaching maturity, silver sagebrush and western wheatgrass were being established. Noxious species, including leafy spurge, Russian olive, and salt cedar, were observed throughout the riparian corridor (NRCS, 2002).

1 Graminoid and forbs refer to grasses and grass-like plants, including sedges and rushes and broad-leaved herbaceous plants, respectively.

Table 2-12. Vegetative characteristics within the riparian corridor of Powder River watershed: Montana portion of the watershed.

Description	Area (acres)	Sq. Miles	Percent
Mixed Grass Prairie	59,714	93.3	30.13
Graminoid and Forb Riparian	27,886	43.6	14.07
Mixed Xeric Shrubs	19,421	30.3	9.80
Shrub Riparian	14,954	23.4	7.54
Forest Riparian	14,103	22.0	7.12
Dryland Crops	11,349	17.7	5.73
Sagebrush	9,405	14.7	4.75
Ponderosa Pine	6,411	10.0	3.23
Badlands	5,949	9.3	3.00
Mesic Shrub-Grassland	4,774	7.5	2.41
Water	3,775	5.9	1.90
Mixed Riparian	3,713	5.8	1.87
Xeric Shrub-Grassland	3,573	5.6	1.80
Irrigated Crops	2,746	4.3	1.39
Mixed Mesic Shrubs	2,200	3.4	1.11
Mixed Barren	1,877	2.9	0.95
Low-Density Xeric Forest	1,707	2.7	0.86
Altered Herbaceous	1,603	2.5	0.81
Juniper Woodland	767	1.2	0.39
Mixed Broadleaf Forest	630	1.0	0.32
Rock Outcrop	556	0.9	0.28
Limber Pine	542	0.8	0.27
Burned Conifer	364	0.6	0.18
Mixed Broadleaf and Conifer	184	0.3	0.09
Total	198,203	309.7	100.00

The proportions of riparian vegetation classes in the Wyoming portion of the watershed are similar to those in Montana, although the forested riparian proportion is a bit greater. This is a reflection of higher elevations and slightly more precipitation in Wyoming. A total of 367,314 riparian acres exist in the Wyoming portion of the watershed, and 102,657 of these acres (27.95 percent) are in sagebrush vegetation (see Table 2-13). Another 71,509 acres (19.47 percent) consist of mixed grass prairie, and forest riparian comprises 64,934 acres (17.68 percent) of the riparian corridor. Additionally, irrigated crops, grass riparian and shrub riparian comprise 21,443 acres (5.84 percent), 21,403 acres (5.83 percent), and 16,637 acres (4.53 percent), respectively, within the riparian corridor.

Table 2-13. Vegetative characteristics within the riparian corridor of Powder River watershed: Wyoming portion of the watershed.

Description	Area (ac)	Sq. Miles	Percent
Sagebrush	102,657	160.4	27.95
Mixed Grass Prairie	71,509	111.7	19.47
Forest Riparian	64,934	101.5	17.68
Irrigated Crops	21,443	33.5	5.84
Grass Riparian	21,403	33.4	5.83
Shrub Riparian	16,637	26.0	4.53
Dryland Crops	14,365	22.4	3.91
Ponderosa Pine	14,321	22.4	3.90
Lodgepole Pine	12,866	20.1	3.50
Desert Shrub	7,176	11.2	1.95
Mixed Xeric Shrubs	3,571	5.6	0.97
Alpine Meadow	3,445	5.4	0.94
Juniper Woodland	2,186	3.4	0.60
Rock Outcrop	2,136	3.3	0.58
Clearcut Conifer	1,849	2.9	0.50
Saltbrush/Salt Flats	1,623	2.5	0.44
Douglas Fir	1,559	2.4	0.42
Water	1,025	1.6	0.28
Surface Mining	871	1.4	0.24
Burned Conifer	693	1.1	0.19
Whitebark Pine	452	0.7	0.12
Aspen Forest	428	0.7	0.12
Urban/Developed Land	166	0.3	0.05
Total	367,314	573.9	100.00

2.1.10.2 Channel Morphology

NRCS assessed the conditions of major streams in the Powder River watershed in Montana in the summer of 2002 (NRCS, 2002). As part of this study, NRCS personnel described the channel morphology of the Powder River and Little Powder River in Montana. Overall, streams in the watershed are low gradient, sinuous streams that have localized regions of entrenchment based on site-specific conditions. Descriptions of the channels and floodplains from the NRCS report are summarized below.

> *Powder River – Low gradient, high sinuosity, and a high bedload system characterized the Powder River. Overall, the river corridor appears to be functioning within the range of its inherent potential and its appearance was probably very similar to that found by early day explorers. The floodplain is in general readily available to frequent flood events at least on one bank. Riparian vegetation appeared to be very important to the stability of this river given there are few areas with natural bedrock control. The river downcut in the past and is actively moving laterally within a lower floodplain. Several old floodplains, now terraces above the channel, were usually visible. Most of this appeared to be natural as evidenced by meander cutoffs or oxbows.*

Little Powder River – The Little Powder River was found to be a perennial, low gradient, highly meandering system flowing though a relatively wide valley. In the upper reaches, the channel profile and pattern resembled a meadow type stream with an accessible floodplain, and a relatively narrow and deep channel. The middle section beginning at about Reach 4 showed evidence of old downcutting with limited floodplain access. The valley and gradient narrows in this area increasing flood velocity and may have contributed to past downcutting. Above the mouth, the Little Powder River flowed in a wide, abandoned channel of the Powder River creating ponded, wetland-like conditions with cattails and bulrush immediately adjacent to the channel.

2.2 Cultural Characteristics

2.2.1 Population

The total population for the watershed is not directly available but may be inferred from the 2000 U.S. Census data. The 2000 U.S. Census data were downloaded for all towns, cities and counties whose boundaries lie wholly or partially within the watershed. Urban populations for each county were determined by summing the populations of all towns and cities located within the watershed. Nonurban populations for each county were determined by first subtracting the county urban population totals from the county population total. Since only portions of various counties are found within the watershed, a nonurban population weighting method was used to estimate each county's contribution of nonurban population to the total watershed population. The proportion of county area within the watershed was determined from spatial overlay in a GIS of county boundaries and the watershed boundary. It is assumed that the nonurban population for each county is uniformly distributed within the county. The nonurban county population was multiplied by the county's proportional watershed area and the product was assumed to reflect the county nonurban population.

The analysis found that approximately 23,000 people reside within the Powder River watershed, and that the Wyoming portion of the watershed has a more urban character. The watershed urban and nonurban population totals by county are given in Table 2-14. Figure 2-1 displays the locations of counties and the larger cities and towns. From the table, it can be seen that 16,317 people, or 71.3 percent of the population, live in nonurban areas, while 6,571 people (28.7 percent) reside in cities and towns. Johnson County, Wyoming, has the largest total population in the watershed with 9,788 people (42.8 percent), and it also has the largest urban population of 5,639, (18 percent). The second largest total county population is found in Powder River County, Montana, with 3,750 people, (16.4 percent).

A review of Table 2-14 reveals that population distribution by state is very similar. The Wyoming portion of the Powder River watershed is home to 12,436 people, which represents 54.3 percent of the total watershed population, and Montana contributes 10,452 persons, or 45.7 percent, to the watershed population total.

Urban population centers in the Powder River watershed are listed in Table 2-15. The total urban population in the watershed is 6,571 people, distributed among twenty towns, each with small populations. The largest town is Buffalo, in Johnson County, Wyoming, with 3,900 people. The other towns all have populations of less than 1,000 people. The largest urban center in the Montana portion of the watershed is the town of Powder River with a population of 559 people. In general, there is a greater urban population in the Wyoming portion of the watershed, although there are a greater number of towns in the Montana portion. Summarized by state, the Wyoming portion of the watershed has 5,812 persons living in urban places, while the Montana portion has 759 persons in urban places.

Table 2-14. Powder River watershed population summarized by county.

County	Total Watershed Population	Percent of Total Population	Non-urban Population	Percent Non-urban	Urban Population	Percent Urban
Johnson, WY	9,788	42.8	5,639	24.6	4,149	18.1
Powder River, MT	3,750	16.4	3,051	13.3	699	3.1
Carter, MT	3,446	15.1	3,426	15.0	20	0.1
Prairie, MT	2,184	9.5	2,184	9.5	0	0.0
Custer, MT	1,072	4.7	1,032	4.5	40	0.2
Sheridan, WY	1,058	4.6	23	0.1	1,035	4.5
Converse, WY	721	3.2	721	3.2	0	0.0
Natrona, WY	695	3.0	67	0.3	628	2.7
Campbell, WY	125	0.5	125	0.5	0	0.0
Crook, WY	25	0.1	25	0.1	0	0.0
Washakie, WY	24	0.1	24	0.1	0	0.0
Total	22,888	100.0	16,317	71.3	6,571	28.7

Source: U.S. 2000 Census and GIS analysis.

Table 2-15. Urban population centers in the Powder River watershed.

City/Town	Population	County	State
Buffalo	3,900	Johnson	WY
Story	887	Sheridan	WY
Broadus	559	Powder River	MT
Midwest	408	Natrona	WY
Kaycee	249	Johnson	WY
Edgerton	169	Natrona	WY
Clearmont	115	Sheridan	WY
Powder River	51	Natrona	WY
Belle Creek	40	Powder River	MT
Arvada	33	Sheridan	WY
Biddle	20	Powder River	MT
Boyes	20	Carter	MT
Coalwood	20	Powder River	MT
Epsie	20	Powder River	MT
Mizpah	20	Custer	MT
Olive	20	Powder River	MT
Knowlton	10	Custer	MT
Locate	10	Custer	MT
Moorhead	10	Powder River	MT
Powderville	10	Powder River	MT
Total Urban Population	6,571		

Source: U.S. 2000 Census and GIS analysis.

2.2.2 Land Ownership

Various private, tribal, state and federal agencies hold title to portions of the Powder River watershed, as shown in Figure 2-26. Land ownership is summarized for the watershed as a whole in Table 2-16, and Table 2-17 summarizes land ownership by state. For the watershed as a whole, the majority of land is privately owned (see Table 2-3), consisting of 5,655,985 acres, or 65.9 percent of the watershed area. Federal land holdings, represented by agencies such as the Bureau of Land Management (BLM) and the U.S.Forest Service (Forest Service), comprise a total of 2,143,707 acres, or roughly 25 percent of the watershed area. The BLM is the largest federal landowner in the watershed, and represents the second largest land ownership in the watershed overall with 1,804,476 acres, which comprises 21.0 percent of the total watershed area. Land holdings by the state of Wyoming, the Forest Service, and the state of Montana represent 6.4 percent, 4.0 percent, and 2.6 percent of total watershed area, respectively.

Table 2-16. Land ownership in the Powder River watershed.

Land Ownership Description	Area (Acres)	Percentage
Private lands	5,655,985	65.9
U.S. Bureau of Land Management	1,804,476	21.0
Wyoming State Lands	546,194	6.4
U.S. Forest Service	339,231	4.0
Montana State Lands	223,349	2.6
U.S. Department of Defense	9,345	0.1
Total	8,578,580	100.0

The watershed wide characteristics of land ownership given in Table 2-16 are very similar when ownership is examined by state. Table 2-16 presents land ownership for the Montana and the Wyoming portions of the Powder River watershed. As shown in the table, the majority of land ownership consists of privately held land in Montana and Wyoming, comprising 70.4 percent and 64.0 percent, respectively, of the watershed area within each state. The proportion of BLM land ownership is roughly equivalent in Montana (19.6 percent) and Wyoming (21.7 percent). Additionally, the proportion of state-owned lands is almost equal in the Montana (8.6 percent) and the Wyoming (8.8 percent) portions of the watershed. One major difference in land ownership between the two states is identified in Table 2-17. Forest Service ownership is much smaller in the Montana portion of the Powder River watershed (1.4 percent) compared to Wyoming (5.1 percent). This is primarily due to topographic differences, mainly lower elevation, and consequently less precipitation and therefore less forested area in Montana.

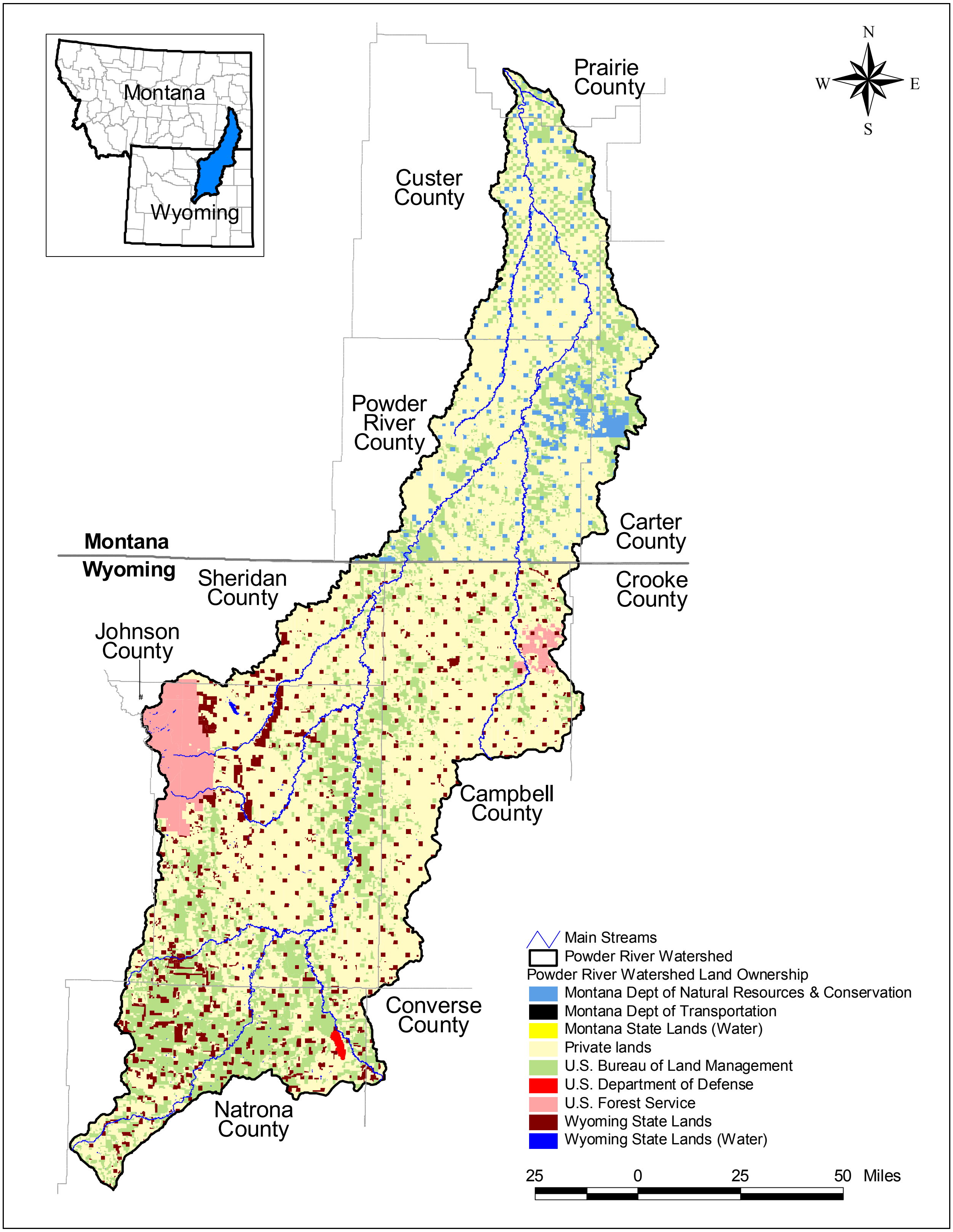

Figure 2-26. Land ownership in the Powder River watershed.

Table 2-17. Land ownership by state in the Powder River watershed.

Montana		
Land Ownership Description	**Area (Acres)**	**Percent**
Private land (undifferentiated)	1,828,661	70.4
Bureau of Land Management	508,771	19.6
Montana State Lands	223,346	8.6
U.S. Forest Service	35,183	1.4
Montana Dept of Transportation	3	<0.1
Total	2,595,964	100.0

Wyoming		
Land Ownership Description	**Acres (Acres)**	**Percent**
Private lands	3,827,324	64.0
U.S. Bureau of Land Management	1,295,705	21.7
Wyoming State Lands	531,012	8.8
U.S. Forest Service: National Forest	200,464	3.4
U.S. Forest Service: Wilderness Area	60,091	1.0
U.S. Forest Service: National Grassland	43,493	0.7
Wyoming State Wildlife Habitat Management Unit	15,182	0.3
U.S. Department of Defense	9,345	0.2
Total	5,982,616	100.0

2.2.3 Economics

The four counties in the Powder River watershed in Montana – Carter County, Custer County, Powder River County, and Prairie County – all support a primarily rural economy. Custer County has the most number of people of the four counties and the largest work force (Table 2-18). Unemployment rates in 2000 were below the state average of 4.9 percent in all four counties (Table 2-19).

The median household incomes in 2000 for Carter, Custer, Powder River, and Prairie counties were \$26,313, \$30,000, \$35,898, and \$25,451, respectively (U.S. Census Bureau, 2000). Most people in Carter, Powder River, and Prairie Counties were employed by the agricultural, forestry, fishing, hunting, and mining sectors (U.S. Census Bureau, 2000). The educational, health, and social services industry employed the most people in Custer County (Table 2-20). A large percentage of people worked in the agriculture, forestry, fishing, hunting, and mining industry in all four counties. Table 2-21 summarizes the agricultural economics data for each county in the Powder River watershed. On average, almost 27 million dollars in revenue were generated per county in 1997 for agricultural products (NASS, 1997).

Table 2-18. Summary of population and work force data per county[a].

County	Total Population	Total Population Greater than 15 Years Old	Number of People in the Labor Force	Total Number of Households
Carter	1,360	1,066	747	543
Custer	11,696	9,203	5,869	4,768
Powder River	1,858	1,424	961	737
Prairie	1,199	997	600	537

Source: U.S. Census Bureau, 2000.
[a]Population data are presented for the entire county, not just the portion within the Powder River watershed.

Table 2-19. Unemployment rates by county[a].

County	1995 Rate (%)	2000 Rate (%)	% Change
Carter	1.8	2.1	0.3
Custer	4.6	4.4	-0.2
Powder River	2.4	2.9	0.5
Prairie	4.6	4.3	-0.3

Source: MDLI, 2001 (adapted from USDI, 2002).
[a]Unemployment data are presented for the entire county, not just the portion within the Powder River watershed.

Table 2-20. Employment by sector in 2000 (percent)[a].

Industry	Carter County	Custer County	Powder River County	Prairie County
Agriculture, forestry, fishing, hunting, and mining	56.7	10.6	43.0	36.0
Construction	4.7	5.1	4.0	4.7
Manufacturing	0.5	2.4	1.6	1.2
Wholesale trade	1.2	2.2	1.2	2.1
Retail trade	3.1	14.1	6.6	5.5
Transportation/warehousing/utilities	2.2	4.7	3.8	4.3
Information	0.9	1.4	1.9	1.6
Finance, insurance, real estate, and rental and leasing	2.0	4.0	2.3	2.8
Professional, scientific, management, administrative, and waste management services	2.0	3.6	1.5	2.3
Educational, health and social services	13.2	27.5	17.2	22.2
Arts, entertainment, recreation, accommodation and food services	6.7	10.0	7.6	5.7
Other services (except public administration)	4.0	5.9	3.5	5.4
Public administration	2.7	8.6	5.8	6.2

Source: (U.S. Census Bureau, 2000).
[a] Employment data are presented for the entire county, not just the portion within the Powder River watershed.

Table 2-21. Summary of agricultural economics data for 1997[a].

	Carter County	Custer County	Powder River County	Prairie County	Average
Farms (number)	305	405	297	158	291
Land in farms (acres)	1,589,372	1,897,536	1,559,222	612,906	1,414,759
Total cropland (acres)	244,923	170,277	165,614	123,251	176,016
Market value of agricultural products sold	$26,991,000	$32,586,000	$27,293,000	$20,292,000	$26,790,500
Market value of agricultural products sold, average per farm	$88,494	$80,459	$91,895	$128,428	$97,319

Source: NASS, 1997.
[a]Agricultural data are presented for the entire county, not just the portion within the Powder River watershed.

2.3 Fisheries

The Montana Fisheries Information System (MFISH) contains information on fish species in Montana's rivers. Fish species found in the Powder River, Mizpah Creek, and the Little Powder River are shown in Table 2-22. MFISH classified most of the Powder River as a high-value fishery (NRIS, 2002). However, periodic dewatering is a concern to fish throughout the Powder River in Montana. The Little Powder River was classified as a substantial fishery, and Mizpah Creek is classified as a moderate to limited fishery. No information was available for fish stocking in the Powder River, Mizpah Creek, or the Little Powder River.

Table 2-22. Fish species in the Powder River, Little Powder River, and Mizpah Creek, Montana.

Species	Little Powder River	Mizpah Creek	Powder River
Black Bullhead		X	
Bluegill		X	
Brassy Minnow			X
Brook Trout			X
Brown Trout			X
Burbot			X
Channel Catfish	X	X	X
Common Carp	X	X	X
Creek Chub	X	X	X
Fathead Minnow	X	X	X
Flathead Chub	X	X	X
Goldeye	X	X	X
Green Sunfish	X	X	X
Largemouth Bass		X	
Longnose Dace	X	X	X
Longnose Sucker			X
Plains Killifish			X
Plains Minnow	X	X	X
Rainbow Trout			X
River Carpsucker	X	X	X
Sand Shiner	X	X	X
Sauger			X
Sauger X Walleye Hybrid			X
Shorthead Redhorse	X	X	X
Shovelnose Sturgeon			X
Smallmouth Buffalo		X	
Stonecat	X		X
Sturgeon Chub			X
Walleye			X
Western Silvery Minnow			X
Western Silvery/Plains Minnow	X	X	X
White Sucker	X	X	X

Source: NRIS, 2002.

3.0 WATER QUALITY CONCERNS AND STATUS

This section of the document first presents the 303(d) list status of all listed water bodies within the TPA (i.e., which water bodies are listed as impaired or threatened and for which pollutants). This is followed by a description of the parameters of concern, the applicable water quality standards, a water body by water body review of available water quality data, and, finally, an updated water quality impairment status determination for each listed water body.

3.1 Montana 303(d) List Status

The Montana 1996 303(d) list reported that beneficial uses in the Powder River, Little Powder River, Stump Creek, and Mizpah Creek were impaired for a variety of reasons. The listing information from the report is shown in Table 3-1. The Powder River, Little Powder River, and Stump Creek were not assessed for beneficial use impairments for the 2002 303(d) list. Both lists reported that Mizpah Creek was fully supporting aquatic life and warm water fishery uses. Other uses in Mizpah Creek were not assessed. Table 3-2 shows the Wyoming 2002 303(d) list for the Powder River watershed. Figure 3-1 shows the location of the Powder River watershed, major streams, and the impaired river segments from the 1996 303(d) list.

Table 3-1. 1996 listing information for the Powder River watershed.

Segment Name	USGS HUC	Estimated Size (mi)	Probable Impaired Uses	Probable Causes	Probable Sources
Lower Powder River	10090209	134	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Metals Nutrients Other Inorganics Salinity/TDS/Chlorides Suspended Solids Flow Alteration Pathogens	Agriculture Irrigated Crop Production Natural Sources Petroleum Activities Resources Extraction Range Land Streambank Modification/Destabilization
Little Powder River	10090208	51	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Salinity/TDS/Chlorides Other Inorganics Suspended Solids Siltation Flow Alteration	Irrigated Crop Production Natural Sources Streambank Modification/Destabilization
Stump Creek	10090209	4	Aquatic Life Support	Suspended Solids	Agriculture Range Land
Mizpah Creek	10090210	80	Agriculture Recreation Aquatic Life Support Drinking Water Supply Swimmable Warmwater Fishery	Organic Enrichment/DO Other Inorganics Suspended Solids	Irrigated Crop Production Natural Sources Range Land

Source: MDEQ, 1996.

Table 3-2. Wyoming 2002 303(d) list for the Powder River watershed.

Name	Location	Cause	Source	Impaired/Threatened Uses
Waterbodies with Water Quality Impairments				
Powder River	South Fork Powder River to below Sussex	Selenium	Undetermined	Warmwater fishery, aquatic life, wildlife
Powder River	From Salt Creek to below Sussex	Chloride	Undetermined	Warmwater fishery, aquatic life
Salt Creek	From the Powder River upstream	Chloride	Undetermined	Nongame fish, aquatic life
Crazy Woman Creek	From the Powder River upstream	Manganese	Undetermined	Drinking water
Waterbodies with Water Quality Threats				
Salt Creek	Downstream from oil fields	Oil spills	Undetermined	Non-game fish, aquatic life
North Fork Crazy Woman Creek	Reaches within T49N R82W	Habitat degradation; Nutrients	Non-point	Coldwater fishery, aquatic life
Hunter Creek	S10 T50N R84W-11 mi. W. of Buffalo	Heavy siltation	Non-point	Coldwater fishery, aquatic life
Rock Creek	Watershed below Forest Boundary, tributary to Clear Creek	Habitat degradation	Non-point	Coldwater fishery, aquatic life
Shell Creek North Fork	Above Shell Creek Reservoir	Habitat degradation	Non-point	Aquatic life
Shell Creek South Fork	Above Shell Creek Reservoir	Habitat degradation	Non-point	Aquatic life
Little Powder River	Wyoming/Montana state line upstream an undetermined distance	Fecal coliforms	Undetermined point	Contact recreation

Source: WDEQ, 2002.

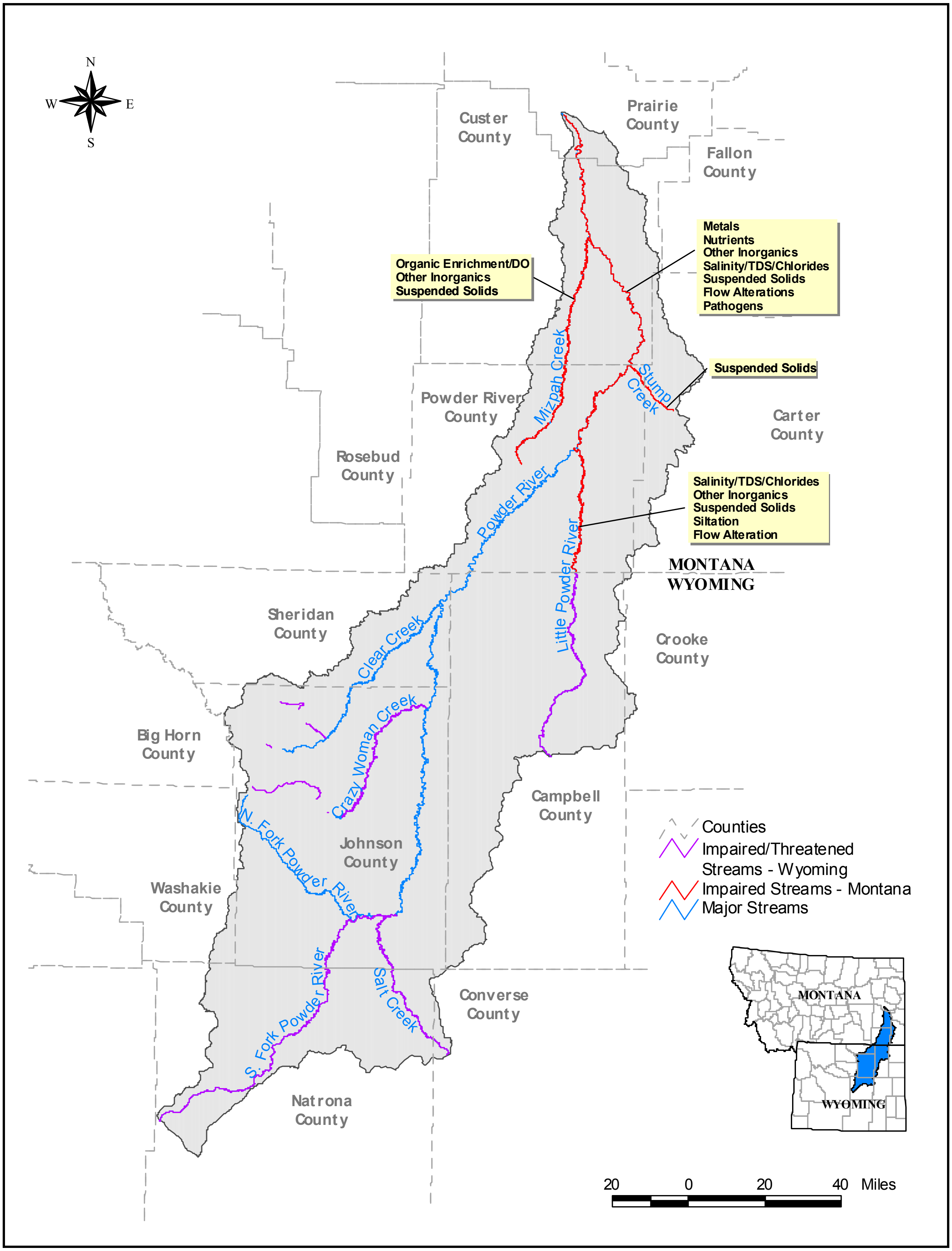

Figure 3-1. Location of the Montana (1996) and Wyoming (2002) impaired streams in the Powder River watershed.

3.2 Parameters of Concern

The following sections provide a summary of the parameters identified on the Montana 1996 303(d) list as causing impairments in the Powder River watershed. The purpose of these sections is to provide an overview of the parameters, units, sampling methods, and potential sources. The relevance of the parameter to the various beneficial uses is also briefly discussed.

3.2.1 Salinity and Total Dissolved Solids

As water flows through a system, particles of soil, rock, and other materials accumulate in the water. The materials dissolve (or dissociate) in the water to form cations (positively charged ions) and anions (negatively charged ions). The term *salinity* refers to the total amount of dissolved cations and anions in water. Major ions in water are generally sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate. Metals (e.g., copper, lead, and zinc) and other trace elements (e.g., fluoride, boron, and arsenic) are usually only minor components of the total salinity. Salinity is determined by measuring the *conductance* of water, which is the opposite of resistance. This is done by sending an electrical current through the water and measuring the *electrical conductivity* (EC). The conductance of the water is corrected to a water temperature of 25 °C, and is sometimes then called *specific conductivity* (SC). In this report, all EC values are corrected to a water temperature of 25 °C. The units for EC are typically microsiemens per centimeter (µS/cm). EC is an easy and cost efficient measurement that can be performed in the field or the laboratory.

The sum of all of the dissolved substances in water is called *total dissolved solids* (TDS), and is measured in milligrams per liter (mg/L). TDS is a laboratory measurement and cannot be determined in the field. Pure distilled water has a TDS of zero. TDS concentrations in rainfall and snowfall vary, and generally range from zero to ten milligrams per liter. In comparison, the average TDS for the lower segment of the Powder River at USGS station 06326500 (April 1–October 31) is 1,419 mg/L.

The salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). Increases or decreases in salinity can cause a shift in the composition of the natural aquatic community. In the Powder River, it is likely that many native aquatic organisms have adapted to the natural moderate salinity. The effects of salinity on non-native species (such as northern pike and rainbow trout) are unknown. Highly saline waters can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. Livestock can also be adversely affected by high salinity values.

Natural sources, such as geology and soils, contribute to the salinity of a stream. Watersheds that have easily erodible soils, or parent materials with high salt concentrations, have streams and lakes that have naturally high salinity. However, there are also several potential anthropogenic sources of salinity. Anthropogenic sources of salinity can occur from agricultural irrigation returns, oil and gas returns (e.g., CBM wells and oil wells), disturbed land, road salting, and agricultural runoff. Proposed CBM development in the Powder River watershed is a major potential source of salinity. Monitoring data from several CBM wells in the Powder River watershed indicated a mean salinity of 2,735 µS/cm (O&G Environmental Consulting, 2001).

3.2.2 Chlorides

Chloride salts are common in the earth's crust and are easily dissolved in water. Sodium chloride is one such salt, and other major chloride salts are calcium chloride and magnesium chloride. These salts accumulate and dissolve in water as it flows through a watershed. Chloride concentrations are measured in the lab and are typically reported in milligrams per liter. Chloride is one of the many salts measured by salinity and TDS. Therefore any increases or decreases in the chloride concentrations of a waterbody will also cause changes in the salinity and TDS.

Chloride salts are one portion of the salinity of water, and the salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). In the Powder River, it is likely that many native aquatic organisms have adapted to the natural moderate chloride concentrations. The effects of chlorides on non-native species (such as northern pike and rainbow trout) are unknown. Chlorides alone can also be toxic to aquatic organisms (USEPA, 1988). Irrigation water with high chloride concentrations can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. Livestock can also be adversely affected by high chloride concentrations.

Natural sources, such as geology and soils, contribute to the chloride concentrations of a stream. There are also several potential anthropogenic sources of chlorides. Potential anthropogenic sources of chlorides are irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), road salting, and urban and agricultural runoff.

3.2.3 Sulfates

Sulfur is found in the rocks and soils of southeastern Montana. Sulfur compounds from the rocks and soils form sulfate ions (SO_4^{-2}) when dissolved in water. Sulfate concentrations are measured in the lab and are typically reported in milligrams per liter. Sulfate is one of the many components measured by salinity and TDS. Therefore any increases or decreases in the sulfate concentrations of a waterbody will also cause changes in the salinity and TDS.

Sulfates are one portion of the salinity of water, and the salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). In the Powder River, it is likely that many native aquatic organisms have adapted to the natural moderate chloride concentrations. The effects of sulfates on non-native species (such as northern pike and rainbow trout) are unknown. Irrigation water with high sulfate concentrations can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. High concentrations of sulfate in water produce unpleasant odors and can have adverse health effects (laxative effect) on humans and livestock.

Natural sources, such as geology and soils, contribute to the sulfate concentrations of a stream. There are also several potential anthropogenic sources of sulfates. Potential anthropogenic sources of sulfates are irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), and agricultural runoff.

3.2.4 Sodium Adsorption Ratio

Sodium, magnesium, and calcium salts are naturally occurring in the bedrock and soils of the Powder River watershed. These salts make their way into streams through weathering processes, runoff, and percolation. The concentrations of calcium, magnesium, and sodium in water are of interest because of the way they interact with soils. When high sodium concentrations are present in water with low calcium and magnesium concentrations, the sodium ions can disperse clay soils. This can change the soil structure and eventually render the soil hard and resistant to water and aeration. The relationship between calcium, magnesium, and sodium in streams is monitored to protect the agricultural uses of the waterbody. The relationship is called the sodium adsorption ratio (SAR), and it is the ratio of sodium to calcium plus magnesium in water. It is calculated with the following formula and the units for the ions are milliequivalents per liter (meq/L). The calculated values for SAR are unitless because it is a ratio.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

The SAR only impacts agricultural uses of a waterbody. The effect of high SAR values on aquatic life, livestock, or drinking water uses is unknown. Individually, calcium, magnesium, and sodium salts all contribute to the salinity of a waterbody.

Natural sources, such as geology and soils, contribute calcium, magnesium, and sodium to waterbodies and therefore affect the SAR. Potential anthropogenic sources of calcium, magnesium, and sodium can occur from agricultural irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), disturbed land, road salting, and urban and agricultural runoff. Anthropogenic sources can increase the SAR by contributing high sodium loads to a waterbody. Proposed CBM development in the Powder River watershed is a major potential source of SAR. Monitoring data from several CBM wells in the Powder River watershed indicated a mean SAR of 22.3 (O&G Environmental Consulting, 2001). For comparison, the average SAR at USGS station 06326500 in the lower Powder River is 4.3.

3.2.5 Nutrients/Organic Enrichment/Low Dissolved Oxygen

The term *nutrients* usually refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Various forms of nitrogen and phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate. Common nitrogen sampling parameters are total nitrogen (TN), nitrite (NO_2), nitrate (NO_3), total Kjeldahl nitrogen (TKN), and ammonia (NH_3). Concentrations are measured in the lab and are typically reported in milligrams per liter.

Nutrients generally do not pose a direct threat to the beneficial uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth. This process is called eutrophication or organic enrichment. Organic enrichment can have many effects on a stream or lake. One possible effect of eutrophication is low dissolved oxygen concentrations. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Dissolved oxygen concentrations are measured in the field and are typically reported in milligrams per liter. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. Recreational uses can be impaired because of eutrophication. Nuisance plant and algae growth can interfere with swimming, boating, and fishing. Nutrients generally do not pose a threat to agricultural uses.

Nitrogen and phosphorus exist in rocks and soils and are naturally weathered and transported into waterbodies. Organic matter is also a natural source of nutrients. Systems rich with organic matter (e.g., wetlands and bogs) can have naturally high nutrient concentrations. Phosphorus and nitrogen are potentially released into the environment through different anthropogenic sources including septic systems, wastewater treatment plants, fertilizer application, and animal feeding operations.

3.2.6 Metals

The metals of concern for the Powder River watershed are cadmium, chromium, copper, iron, lead, nickel, silver, and zinc. For the purpose of this report, arsenic and selenium are also analyzed with the metals data. The procedures used to sample metals in the field and analyze metals in the laboratory have changed substantially over time. General speculation is that historical metals sampling results are often questionable because of possible contamination during collection and processing. New metals procedures set by USEPA have been implemented to ensure clean sampling results (USEPA, 1996). Analytical procedures in the laboratory now have better accuracy and lower detection limits, and smaller metals concentrations can be detected. Because some data are questionable, only metals data from 1996 to present are analyzed in this report. Metals data are typically reported in micrograms per liter (µg/L).

Metals usually present a threat to the health of aquatic life, animals, and humans because of toxicity. The toxic effects of metals often change with the hardness of water. The effects on agricultural uses of water are not well known.

Potential sources of metals include natural sources (e.g., geology and soils) and anthropogenic sources such as industrial discharges, CBM, oil, and coal mine discharges, wastewater treatment plants, septic systems, and urban runoff.

3.2.7 Total Suspended Solids/Siltation

Excess total suspended solids (TSS) in a stream can pose a threat to aquatic organisms. Turbid waters created by excess TSS concentrations reduce light penetration, which can adversely affect aquatic organisms. Also, TSS can interfere with fish feeding patterns because of the turbidity. Prolonged periods of very high TSS concentrations can be fatal to aquatic organisms (Newcombe and Jensen, 1996). As TSS settles to the bottom of a stream, critical habitats such as spawning sites and macroinvertebrate habitats can be covered in sediment. This is referred to as *siltation*. Excess sediment in a stream bottom can reduce dissolved oxygen concentrations in stream bottom substrates, and it can reduce the quality and quantity of habitats for aquatic organisms. TSS can also pose a threat to recreational uses because of murky conditions and muddy stream bottoms. High levels of TSS in irrigation waters can clog irrigation ditches and drainage pumps.

Erosion and overland flow contribute some natural TSS to most streams. In watersheds with highly erodible soils and steep slopes, natural TSS concentrations can be very high. Excess TSS in overland flow can occur when poor land use and land cover practices are in place. This potentially includes grazing, row crops, construction activities, road runoff, and mining. Grazing and other practices that can degrade stream channels are other possible sources of TSS.

3.2.8 Pathogens

To help ensure safe, swimmable surface waters, routine monitoring for entero-pathogens (enterococcal bacteria, viruses, and protozoa that can cause gastrointestinal diseases and are disseminated through fecal contamination) is necessary. Direct monitoring of entero-pathogens that can cause serious diseases, such as cholera, typhoid, salmonellosis, and dysentery, is not feasible since these organisms are difficult to detect directly. Instead, an indicator organism, such as total coliforms, fecal coliforms, or *Escherichia coli* (E. coli), is used to determine fecal contamination. The Montana standard for pathogens is for fecal coliforms. Fecal coliforms are a reliable indicator of fecal contamination, and are a subset of the total coliform bacteria group. Concentrations are measured in the lab and are typically reported as the count of organisms in 100 milliliters of water (count/100 mL). Fecal coliform concentrations at a particular site may vary depending on the baseline bacteria level already in the river, inputs from other sources, dilution with precipitation events, and die-off or multiplication of the organism within the river water and sediments. The concentration of fecal coliforms in surface water depends primarily on the runoff from various sources of contamination, and is related to the land use and hydrology of the watershed.

3.3 Applicable Water Quality Standards

The Powder River watershed is regulated by two jurisdictional entities that have applicable water quality standards – the State of Montana and the State of Wyoming. Wyoming standards are applicable to the Montana border and must be protective of downstream uses. Relative to salinity, the only approved and applicable water quality standards in Montana are narrative in form as promulgated by Administrative Rules of Montana Section 17.30.637. The State of Montana is currently in the process of developing and adopting numeric criteria for EC and SAR to address salinity related issues potentially associated with future CBM discharges.

This section presents the current applicable water quality standards. It also presents the most up to date proposals regarding numeric criteria (as of the time that this report was prepared) including a status report regarding the proposed schedule for, and status of, their adoption.

The uncertainty regarding the timing of review and adoption of Montana's water quality standards is acknowledged herein. It is also acknowledged that the standards presented in this section may change. These standards are presented to provide the best indication of water quality metrics available at this time with which to use as a basis for making water quality impairment determinations. All of the proposed standards are within the same relative range of values for protecting agricultural uses and are therefore considered appropriate for an initial screening of impairment. The final TMDL will be updated as appropriate to reflect the water quality standards that apply at that time.

3.3.1 Montana Standards

All waters in the Powder River watershed in Montana are assigned a C-3 use classification (ARM, 2002). The C-3 classification is described below. All waters in the Powder River watershed have similar beneficial uses. Waters classified as C-3 support non-salmonid fish species, and only marginally support drinking, agricultural, and industrial water supplies.

- C-3: Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation, and growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply. Degradation which will impact established beneficial uses will not be allowed.

3.3.1.1 Narrative Standards

Montana narrative standards address two basic concepts (1) activities that would result in nuisance aquatic life are prohibited, and (2) no increases are allowed over naturally occurring conditions of sediment, settleable solids, oils, or floating solids, which are harmful to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, and other wildlife (ARM, 2002). A summary of the narrative standards that apply to pollutants of concern in the Powder River TPA is shown in Table 3-3 and the full text is included in Appendix C. Aquatic life in the Powder River TPA is protected by several different narrative standards that apply to all of the pollutants of concern. Aquatic life may not be harmed by any anthropogenic source of pollution (ARM 17.30.637(d)), and conditions that produce undesirable aquatic life are prohibited (ARM 17.30.637(e)). Agricultural uses are protected by ARM 17.30.637(d), which states that no anthropogenic source of pollution may create conditions that are harmful to plant or animal life. All of the beneficial uses of a waterbody, whether a direct narrative standard exists or not, must be protected.

Table 3-3. Summary of the Montana narrative water quality standards and affected pollutants.

Rule	Text	Affected Pollutants
ARM 17.30.637	No wastes may be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards.	All Parameters
ARM 17.30.637(d)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.	All Parameters
ARM 17.30.637(e)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create conditions which produce undesirable aquatic life.	All Parameters
ARM 17.30.624; 17.30.625; 17.30.629	The maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units except as permitted in ARM 17.30.637.	Total Suspended Solids
ARM 17.30.624; 17.30.625; 17.30.629	No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.	Total Suspended Solids

3.3.1.2 Numeric Standards

Numeric surface water quality standards have been developed for the protection of beneficial uses. Montana currently has three sets of standards: (1) standards that vary by beneficial use, (2) standards that apply to all surface waters of the state, and (3) standards that apply to specific waters in the state. Numeric standards for all Montana surface waters are summarized in the Montana Department of Environmental Quality (MDEQ) Circular WQB-7 (MDEQ, 2002). The circular contains standards for numerous parameters for the protection of aquatic life and human health. All numeric standards that apply to impaired waters in the Powder River watershed are summarized in Tables 3-4 and 3-5.

REVISED NUMERIC CRITERIA

On August 29, 2002, the Montana Board of Environmental Review proposed numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for electrical conductivity (EC) and sodium adsorption ratio (SAR). All available water quality data are compared to these proposed standards in the main text of this document. On December 6, 2002, the Montana Board of Environmental Review instructed DEQ to prepare a supplemental notice of rulemaking regarding the adoption of numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for EC and SAR. This supplemental notice included a revised set of numeric criteria for EC and SAR. Insufficient time was available to modify this document to include consideration of these revised criteria. DEQ's new standards proposal is presented in Appendix D. A preliminary comparison of the revised numeric criteria to available water quality data for the Powder River watershed is presented in Appendix E. The forthcoming final TMDL document will be based on consideration of the approved and adopted water quality standards (for all appropriate jurisdictions) available at that time.

The metals standards for Montana are for total recoverable (TR) metals in a waterbody. In some cases, dissolved metals data were collected in the Powder River watershed. These data were compared to the Montana standards by converting the TR metals standards to dissolved standards using conversion factors developed by USEPA (USEPA, 1996b). The conversion factors and the calculated dissolved metals standards are shown in Appendix F.

Montana has proposed standards for salinity (measured as EC at 25 degrees Celsius) and SAR (see text box) (MDEQ, 2002b, 2002c). Table 3-6 provides a summary of EC standards for the Powder River watershed. These are the draft salinity standards proposed by MDEQ on August 29, 2002. The proposed SAR standard (August 29, 2002) varies depending on the salinity of the water. Under the proposed standards, the instantaneous SAR in a waterbody may not exceed the value given by the equation [(EC*0.0071) – 2.475]. At an EC of 350 µS/cm or less, the formula indicates that the allowable SAR is less than zero. Because of this nonsensical result, the formula does not apply when the EC is 350 µS/cm or less. When the formula given above for calculating the proposed SAR standard results in a value greater than 5, the SAR standard is 5. The proposed formula and conditions for SAR apply year-round to all waters in the Powder River watershed. This is a draft SAR standard proposed by MDEQ at the time of this report. SAR standards might change in the future (see text box above). Montana water quality standards do not include numeric criteria for suspended solids, nutrients, or other inorganics.

Table 3-4. Montana numeric surface water quality standards for all waters in the state.

Parameter	Aquatic Life (acute) (µL)[a]	Aquatic Life (chronic) (µL)[b]	Human Health (µL)[a]
Aluminum (dissolved), (pH 6.5-9.0 only)	750	87	—
Arsenic (TR)	340	150	18
Barium (TR)	—	—	2,000
Cadmium (TR)	1.05 @ 50 mg/L hardness[c]	0.16 @ 50 mg/L hardness[c]	5
Chromium (III) (TR)	1,804 @ 100 mg/L hardness[c]	86 @ 100 mg/L hardness[c]	—
Copper (TR)	7.3 @ 50 mg/L hardness[c]	5.2 @ 50 mg/L hardness[c]	1,300
Iron (TR)	—	1,000	—
Lead (TR)	82 @ 100 mg/L hardness[c]	3.2 @ 100 mg/L hardness[c]	15
Nickel (TR)	261 @ 50 mg/L hardness[c]	29 @ 50 mg/L hardness[c]	100
Selenium	20	5	50
Silver (TR)	4.1 @ 100 mg/L hardness[c]	—	100
Zinc (TR)	67 @ 50 mg/L hardness[c]	67 @ 50 mg/L hardness[c]	2,000
Fecal coliforms	The geometric mean of fecal coliforms in waters in the Powder River must be less than 200 coliforms per 100 mL and no more than 10 percent of the samples during a 30-day period shall exceed 400 coliforms per 100 mL. Numeric standards for fecal coliforms in the Powder River watershed are only applied when the daily maximum water temperature is greater that 60 °F, and standards for organisms of the coliform group are based on a minimum of 5 samples obtained during separate 24-hour periods during any consecutive 30-day period analyzed by the most probable number or equivalent membrane filter methods.		
pH	Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 must be less than 0.5 pH units. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.		

[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]Standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L) (see Appendix F for the coefficients to calculate the standard).
Note: TR – total recoverable.

Table 3-5. Aquatic life standards for dissolved oxygen (mg/L) for C-3 streams.

Time Period	Early Life Stages[a]	Other Life Stages
30-day average	NA	5.5
7-day average	6.0	NA
7-day average minimum	NA	4.0
1-day minimum	5.0	3.0

[a]These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

Table 3-6. Proposed EC (µS/cm) standards for agricultural uses.

Waterbody	April 1–October 31	November 1–March 31
Little Powder River, Main stem	1,900	2,000
Little Powder River, Tributaries	500	2,000
Powder River, Main stem	1,900	2,000
Powder River, All Other Tributaries	500	2,000

3.3.1.3 Petitioner Standards

Several different agencies in the Tongue River, Powder River, and Rosebud Creek watersheds have petitioned the Montana Board of Environmental Review to establish SAR and salinity standards. The agencies are the Tongue River Water Users (TRWU), Tongue and Yellowstone Irrigation District (T&Y), Buffalo Rapids Irrigation District (Buffalo Rapids), and Northern Plains Resource Council (Northern Plains). These four groups are collectively referred to as the Petitioners. Standards have been proposed for the Powder River, Tongue River, and Rosebud Creek (TRWU et al., 2002). Proposed standards are maximum values that are not to be exceeded. Values are shown in Table 3-7. At the time of this report, these standards were presented to the Montana Board of Environmental Review, and they are part of the formal rulemaking process to develop salinity and SAR standards for the Powder River TPA. They are not to be interpreted as additional or enforceable standards for the watershed, and are simply presented here to illustrate the range of standards currently being considered.

Table 3-7. Petitioner's proposed EC and SAR standards.[a]

Segment and Dates	EC (µS/cm)	SAR
Powder River at Moorhead, MT		
April 15–July 15	1,400	4.0
July 16–September 1	2,200	5.0
September 2–April 14	3,000	6.0
Powder River at the mouth		
April 15–July 15	1,600	4.0
July 16–September 1	2,400	5.0
September 2–April 14	3,200	6.0
Little Powder River at Biddle, MT		
April 15–July 15	2,000	5.0
July 16–September 1	2,400	6.0
September 2–April 14	3,000	8.0

[a]Maximum values not to be exceeded.
Source: TRWU et al., 2002.

3.3.1.4 Use Support Guidelines

Montana has use support guidelines to determine use impairments based on various sampling parameters. The aquatic life and fisheries use support guidelines for chemistry data consist of narrative and numeric criteria to determine use impairments (MDEQ, 2000). The guidelines for determining the degree of aquatic life use impairment using chemistry data (nutrients, DO, suspended solids, and temperature) are shown below.

Unimpaired – Water quality standards are not exceeded for any pollutant; or the measurements are similar to reference conditions; and/or for one parameter only, the water quality standard is randomly exceeded by no more than 10 percent of the samples in a large dataset.

Moderately Impaired – Water quality standards are exceeded by less than or equal to 50 percent (parameters that do not have numeric values will be compared to reference conditions), or the water quality standards are exceeded by 11 to 25 percent of the samples from a large dataset.

Severely Impaired – Water quality standards are exceeded by more than 50 percent (parameters that do not have numeric values will be compared to reference conditions), or the water quality standards are exceeded by more than 25 percent of the measurements from a large dataset.

The guidelines for determining the degree of aquatic life use impairment because of metals include specifications for addressing acute and chronic criteria. The metals guidelines are shown below.

Unimpaired – No exceedance of acute or chronic standards, and/or the chronic standards are exceeded by less than 10 percent no more than once for one parameter in a three-year period when measurements were taken at least four times/year (quarterly).

Moderately Impaired – Acute standards are exceeded by less than 25 percent; and/or chronic standards are exceeded by 10-50 percent; and/or water quality standards are exceeded in no more than 10 percent of the measurements from a large data set.

Severely Impaired – Acute standards are exceeded by at least 25 percent; and/or chronic standards are exceeded by more than 50 percent; and/or water quality standards are exceeded in more than 10 percent of the measurements from a large data set.

Chronic Criteria Note – When possible, use the average concentration of samples collected over a 96-hour period and compare directly to chronic standard values; one data point (n=1) is sufficient if no other data were collected within 96 hours.

Use support guidelines also suggest that waterbodies should be compared to reference conditions where available. MDEQ states that reference conditions may be determined through a combination of the following:

- Comparison of the waterbody to a less impaired stream
- Historical data showing the previous condition of the waterbody
- Conditions in a less-impaired upstream or downstream segment of the same waterbody
- Conditions in a paired watershed
- A review of pertinent literature or expert opinion
- Modeling

Streams are not impaired when they are determined to be similar to reference conditions. They are moderately impaired when moderately different from reference conditions, and they are severely impaired when severely different from reference conditions. This narrative comparison is used to determine agricultural impairments due to salinity and SAR, as well as aquatic life impairments due to chemical parameters, habitat modification, and siltation.

3.3.2 Wyoming Standards

Wyoming classifies most of the major streams in the Powder River drainage as Class 2AB streams. These streams are protected for drinking water, game fish, nongame fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value uses. Both the main stem Powder River and Little Powder River are Class 2AB streams. However, the main stem of the Little Powder River is classified as a coldwater fishery and the main stem of the Powder River is a warmwater fishery. Most of the tributaries to the Powder River and Little Powder River in Wyoming are classified as Class 3B streams and are protected for other aquatic life, recreation, wildlife, agriculture, industry, and scenic value uses.

3.3.2.1 Narrative Standards

Wyoming has narrative standards to protect all beneficial uses assigned to a waterbody, including industrial, agricultural, and aquatic life uses. Aquatic life uses are generally protected under Sections 28 and 32 of the standards which state that waters must be free of substances that “adversely alter the structure and function of indigenous or intentionally introduced aquatic communities”, and no conditions may be produced which “cause undesirable aquatic life in a waterbody,” (WDEQ, 2001). Agricultural uses of a waterbody are protected so that there shall be no “measurable decrease in crop or livestock production.” Wyoming has chosen not to pursue numeric criteria for SAR and EC. SAR and EC impairments are determined through the use of the narrative standards and implementation procedures for determining those impairments. However, the implementation procedures for determining EC and SAR impairments were not available at the time of this report. A summary of the Wyoming narrative standards is shown in Table 3-8. All Wyoming standards can be accessed on the Internet at http://deq.state.wy.us.

3.3.2.2 Numeric Standards

Numeric surface water quality standards have been developed for the protection of beneficial uses in Wyoming waters. These standards apply to pollutants such as metals, fecal coliforms, pH, and other toxics (WDEQ, 2001). Standards are summarized in Tables 3-9 and 3-10.

Table 3-8. Summary of the Wyoming narrative water quality standards.

Rule	Text	Affected Pollutants
Section 13	Except for those substances referenced in Sections 21 (e) and (f) of these regulations, toxic materials attributable to or influenced by the activities of man shall not be present in any Wyoming surface water in concentrations or combinations which constitute "pollution".	Metals
Section 15	In all Wyoming surface waters, substances attributable to or influenced by the activities of man that will settle to form sludge, bank or bottom deposits shall not be present in quantities which could result in significant aesthetic degradation, significant degradation of habitat for aquatic life or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.	Total Suspended Solids Siltation
Section 16	In all Wyoming surface waters, floating and suspended solids attributable to or influenced by the activities of man shall not be present in quantities which could result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.	Total Suspended Solids Siltation
Section 19	All Wyoming surface waters which have the natural water quality potential for use as an industrial water supply shall be maintained at a quality which allows continued use of such waters for industrial purposes. Degradation of such waters shall not be of such an extent to cause a measurable increase in raw water treatment costs to the industrial user(s). Unless otherwise demonstrated, all Wyoming surface waters have the natural water quality potential for use as an industrial water supply.	All Parameters
Section 20	All Wyoming surface waters which have the natural water quality potential for use as an agricultural water supply shall be maintained at a quality which allows continued use of such waters for agricultural purposes. Degradation of such waters shall not be of such an extent to cause a measurable decrease in crop or livestock production. Unless otherwise demonstrated, all Wyoming surface waters have the natural water quality potential for use as an agricultural water supply.	Salinity SAR
Section 23	In all cold water fisheries and drinking water supplies (classes 1, 2AB, 2A, and 2B), the discharge of substances attributable to or influenced by the activities of man shall not be present in quantities which would result in a turbidity increase of more than ten (10) nephelometric turbidity units (NTUs). (b) In all warm water or nongame fisheries (classes 1, 2AB, 2B and 2C), the discharge of substances attributable to or influenced by the activities of man shall not be present in quantities which would result in a turbidity increase of more than 15 NTUs.	Total Suspended Solids Siltation
Section 28	All Wyoming surface waters shall be free from substances and conditions or combinations thereof which are attributable to or influenced by the activities of man, in concentrations which produce undesirable aquatic life.	All Parameters
Section 32	Class 1, 2 and 3 waters of the state must be free from substances, whether attributable to human induced point source discharges or nonpoint source activities, in concentrations or combinations which will adversely alter the structure and function of indigenous or intentionally introduced aquatic communities.	All Parameters

Table 3-9. Summary of the numeric Wyoming surface water quality standards.

Parameter	Aquatic Life (acute) (µL)	Aquatic Life (chronic) (µL)	Human Health (µL)[b]
Aluminum, *(pH 6.5-9.0 only)*	750	87	
Arsenic	340	150	7
Barium			2,000
Cadmium[c]	4.3	2.2	5
Chloride	860,000	230,000	
Chromium (III)[c]	569.8	74.1	100
Copper[c]	13.4	9	1,000
Iron	1,000	300	
Lead[c]	64.6	2.5	15
Manganese[c]	3,110	1,462	50
Nickel[c]	468.2	52.0	100
Silver[c]	3.4		
Zinc[c]	117.2	118.1	5,000
Fecal coliforms	During the entire year, fecal coliform concentrations shall not exceed a geometric mean of 200 organisms per 100 mL (based on a minimum of not less than 5 samples obtained during separate 24-hour periods for any 30-day period), nor shall the geometric mean of 3 separate samples collected within a 24-hour period exceed 400 organisms per 100 mL in any Wyoming surface water.		
pH	For all Wyoming surface waters, wastes attributable to or influenced by the activities of man shall not be present in amounts which will cause the pH to be less than 6.5 or greater than 9.0 standard units. For all Class 1, 2 and 3 waters, effluent attributable or influenced by human activities shall not be discharged in amounts which change the pH to levels which result in harmful acute or chronic effects to aquatic life, directly or in conjunction with other chemical constituents, or which would not fully support existing and designated uses.		

[a]Metals criteria are for dissolved metals.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]Hardness-dependent criteria. Value given is an example only and is based on a $CaCO_3$ hardness of 100 mg/L. Criteria for each case must be calculated using a formula. See Appendix F.

Table 3-10. Minimum DO criteria[a] (mg/L) for Wyoming waters.

	Coldwater Criteria		Warmwater Criteria	
Period of Time	Early Life Stages[b,c]	Other Life Stages	Early Life Stages[c]	Other Life Stages
30-day mean	NA	6.5	NA	5.5
7-day mean	9.5 (6.5)	NA	6.0	NA
7-day mean minimum[d]	NA	5.0	NA	4.0
1-day minimum[d]	8.0 (5.0)	4.0	5.0	3.0

[a]These limitations apply to Class 1, 2A, 2B, and 2C waters only and in no case may be interpreted to require DO concentrations greater than 100 percent saturation at ambient temperature and elevation.
[b]These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.
[c]Includes all embryonic and larval stages and all juvenile forms to 30 days after hatching.
[d]All minima should be considered as instantaneous concentrations to be achieved at all times.

3.4 Water Quality Impairment Status

This section presents separate summaries and evaluations of all available water quality data for waters appearing on the Montana 1996 303(d) list. A preliminary analysis of the current beneficial use impairment status is also provided. In the absence of current, approved numeric water quality criteria, this section relies on the State's proposed numeric criteria or appropriate surrogate targets where applicable. Water quality impairments were determined using the standards and data available at the time that this report was written. Causes of impairment from the Montana 1996 303(d) list are analyzed. Also, each segment was evaluated for impairments due to salinity, TDS, chlorides, and SAR. A summary of the current impairment status is presented in Table 3-11, including the determination of whether a TMDL is required for each parameter. In general, impairment decisions cannot be made at this time due to a lack of numeric targets or insufficient data. Final water quality impairment determinations will be made in the future as described in Section 1.3. Supporting documentation is provided on a water body by water body basis in the remainder of this section.

Water chemistry data presented in the following sections were downloaded from the USGS National Water Information System (NWIS) database and from MDEQ's STOREASE database. USGS quality assurance/quality control standards (QA/QC) for data contained in the NWIS database are summarized on the NWIS web site at http://waterdata.usgs.gov/nwis/qwdata?help. These include protocols for sampling and analysis, as well as standards for data input and parameter codes. QA/QC standards for the STOREASE database are available from MDEQ's division of Planning, Prevention, and Assistance. All of the available data were input into a Microsoft Access database to allow for storage and retrieval on a site specific or watershed basis. Additional reports, such as macroinvertebrate and periphyton studies, NRCS, FWS, and other miscellaneous studies, were used to help determine water quality impairments. These reports are summarized and documented in the following sections where they are applicable.

Table 3-11. Water quality impairment status summary.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Lower Powder River (from the mouth to the confluence with the Little Powder River)	Chlorides	✔		No
	Flow alteration	✔		No
	Metals	✔		Yes
	Nutrients	✔		Undetermined
	Other inorganics	✔		Undetermined
	Pathogens	✔		Yes
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended solids	✔		Undetermined
	Total dissolved solids	✔		Undetermined
Upper Powder River (from the confluence with the Little Powder River to the state line)	Chlorides			No
	Flow alteration			No
	Metals			Yes
	Nutrients			Undetermined
	Other inorganics			Undetermined
	Pathogens			Yes
	Salinity			Undetermined
	SAR			Undetermined
	Suspended solids			Undetermined
	Total dissolved solids			Undetermined
Little Powder River	Chlorides	✔		No
	Flow alteration	✔		No
	Other inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Siltation	✔		Undetermined
	Suspended solids	✔		Undetermined
	Total dissolved solids	✔		Undetermined
Mizpah Creek	Chlorides			No
	Organic enrichment/DO	✔		Undetermined
	Other inorganics	✔		Undetermined
	Salinity			Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	Total dissolved solids			Undetermined
Stump Creek	Chlorides			No
	Salinity			Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	Total dissolved solids			Undetermined

[a]Not all causes of impairment were evaluated for the 2002 303(d) list.
Source: MDEQ, 1996, 2002.

3.4.1 Powder River

The sections below describe the available water quality data for segments of the Powder River. Data include water quality, macroinvertebrate, periphyton, and habitat analyses. The data were obtained from USGS and MDEQ.

The Montana 1996 303(d) list reported that the Powder River from the mouth to the confluence with the Little Powder River was impaired because of flow alterations, salinity/TDS/chlorides, metals, nutrients, other inorganics, suspended solids, and pathogens (MDEQ, 1996). Impairments due to other inorganics are believed to refer to sulfates. These causes of impairment were impairing agricultural, aquatic life, drinking water, fishery, recreation, and swimmable uses. The upper Powder River was not listed for impairments on the 1996 303(d) list. The Montana 2002 303(d) lists reported that beneficial uses in the lower Powder River and the upper Powder River were not assessed because of insufficient credible data, and no causes of impairment appeared in either list. The discussion below provides a review of available data to evaluate the water quality impairment status.

3.4.1.1 Macroinvertebrates and Periphyton

Periphyton sampling between 1999 and 2000 in the Powder River near Locate, Montana, indicated that aquatic life uses were only partially supported (Bahls, 2000). The major cause of this impairment was sediment. Diatom metrics indicated that there was fair biological integrity and moderate impairment. Pfeiffer et al. (2000) conducted macroinvertebrate sampling at the Locate station and found that the Powder River was not supporting aquatic life uses. No cause of impairment was indicated, but organic enrichment indicators were present. There was no indication of metals toxicity in the macroinvertebrate population. Benthic substrate was monotonous and sediment deposition was severe at the USGS stations near Powderville, Moorhead, and Broadus on the Powder River (Bollman, 2001). Aquatic life uses were moderately impaired at the Moorhead station and slightly impaired at the Broadus and Powderville stations. No cause of impairment was indicated.

3.4.1.2 Fish

The Montana Chapter of the American Fisheries Society (AFS) indicated that the Powder and Little Powder Rivers sustain species of special concern including sauger, sturgeon chub, sicklefin chub, and pearl dace (Clancey, 2002). No information was available as to fish impairments in the Powder River.

3.4.1.3 Water Chemistry Assessment

MDEQ and USGS analyzed water chemistry data at stations throughout the Powder River watershed (Figure 3-2). The different agencies often assigned different station names to similar sites. For the purpose of this report, all data sampled at similar sites were analyzed together and only one station number is reported.

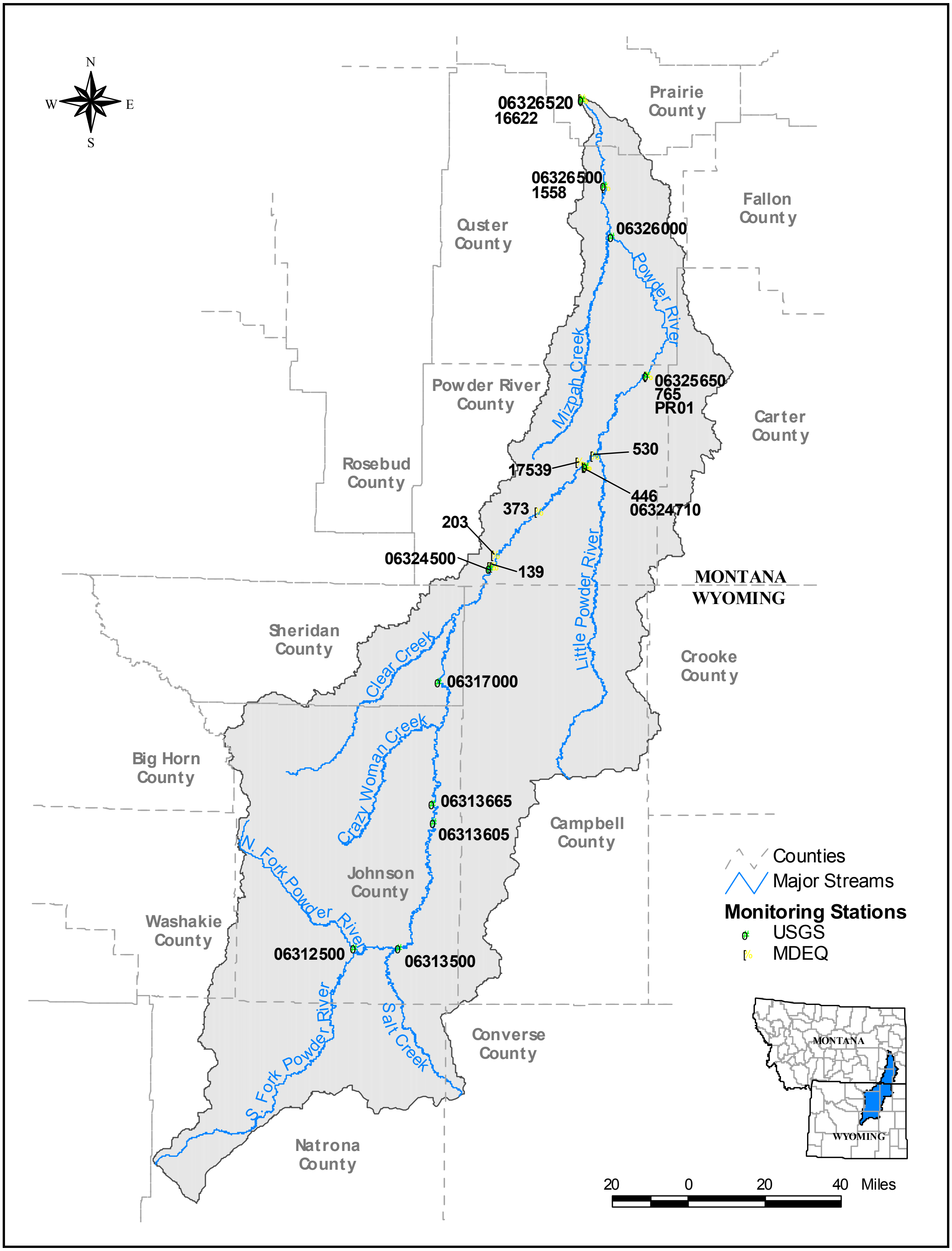

Figure 3-2. Surface water quality monitoring stations in the Powder River watershed.

3.4.1.3.1 Salinity

As described in Section 3.4.1, the lower Powder River was listed as impaired for salinity on the 1996 303(d) list. Agricultural uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and salinity was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to salinity.

EC data are summarized in Tables 3-12 and 3-13 and are compared to the proposed standards in Tables 3-14, 3-15, and 3-16. Figures 3-3 through 3-5 show all available EC data for the lower Powder River, upper Powder River, and the Powder River in Wyoming. Almost all average EC values in Montana were greater than the 1,900 µS/cm criterion. The coefficients of variation were generally low indicating that instantaneous EC values do not vary much from long-term average values. The most recent EC data (1996–2002) indicate that more than 40 percent of EC samples exceed the proposed EC criterion in the lower and upper Powder River.

There is an evident pattern in the average monthly EC values at four USGS stations on the Powder River (Figure 3-6). Average values are lowest in May and June at all four stations. This corresponds to the period of high flow that occurs at these stations (see Section 2.1.3.1). Average values were generally highest during the summer and fall months (July through October), which correspond to the low-flow and growing seasons in the Powder River watershed. Figures 3-7, 3-8, and 3-9 show that there is a weak relationship between EC and flow in the Powder River in Montana. All three relationships show that EC is highest at low flows and lowest during high flows.

A final water quality impairment determination will not be made for salinity (EC) until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-12. Summary of EC data, Powder River (µS/cm) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	9	2,539	1,720	2,910	14%	2/22/74	11/7/89
6326500	316	2,004	409	5,760	35%	12/21/48	2/21/02
Upper Powder							
203	1	1,847	1,847	1,847	NA	2/22/74	2/22/74
6324500	160	2,029	775	3,100	21%	11/26/69	3/29/02
6324710	23	2,042	885	2,910	25%	2/21/74	3/4/92
Wyoming							
6312500	212	1,215	910	1,650	11%	3/02/49	1/07/91
6313500	264	2,345	1,560	3,870	20%	11/15/66	2/02/00
6313605	4	2,250	1,910	2,580	16%	11/16/00	1/10/01
6313665	16	2,923	2,600	3,250	7%	11/28/88	11/02/89
6317000	368	2,526	194	4,300	23%	11/3/48	1/5/00

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-13. Summary of EC data, Powder River (µS/cm) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	22	2,854	1,693	3,850	23%	8/8/74	6/25/01
6326000	10	2,494	1,820	3,300	19%	9/1/78	9/22/01
6326500	641	1,931	338	4,400	36%	8/31/48	10/28/01
6326520	8	2,521	1,860	3,700	26%	9/1/78	9/28/89
Upper Powder							
373	1	3,241	3,241	3,241	0%	7/21/77	7/21/77
530	3	2,971	2,671	3,302	11%	7/22/77	8/18/01
6324500	243	1,888	462	5,000	36%	7/22/69	5/11/02
6324710	84	2,304	500	4,353	41%	5/28/75	9/20/01
Wyoming							
6312500	526	1,143	50	2,600	38%	5/4/46	7/23/91
6313500	472	2,804	655	7,000	50%	10/11/66	8/16/00
6313605	8	3,051	1,640	4,850	41%	5/8/01	8/14/01
6313665	36	4,047	1,500	6,900	44%	8/31/78	9/22/89
6317000	641	2,605	70	6,500	44%	5/3/46	7/15/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-14. Summary of EC Exceedances, lower Powder River.

Season	Salinity Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,900	681	375	55%	54	26	48%
Non-Growing Season	2,000	325	164	50%	32	8	25%
Petitioners (Powder River at the Mouth)[a]							
April 15–July 15	1,600	269	137	51%	27	12	44%
July 16–Sept 1	2,400	226	76	34%	8	4	50%
Non Irrigation Season	3,200	511	33	6%	51	1	2%

[a]Maximum value.
[b]Growing season is from April 1 to October 31.

Table 3-15. Summary of EC exceedances, upper Powder River.

Season	Salinity Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,900	331	175	53%	35	15	43%
Non-growing Season	2,000	184	102	55%	34	11	32%
Petitioners (Powder River at Moorhead, MT)[a]							
April 15–July 15	1,400	144	82	57%	19	14	74%
July 16–Sept 1	2,200	83	58	70%	4	3	75%
Non Irrigation Season	3,000	288	7	2%	46	1	2%

[a]Maximum value.
[b]Grrowing season is from April 1 to October 31.

Table 3-16. Summary of EC exceedances, Powder River in Wyoming.

Season	Salinity Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,900	1,683	865	51%	149	105	70%
Non-growing Season	2,000	864	514	59%	80	54	68%
Petitioners (Powder River at Moorhead, MT)[a]							
April 15–July 15	1,400	761	411	54%	67	31	46%
July 16–Sept 1	2,200	356	232	65%	46	34	74%
Non Irrigation Season	3,000	1,400	224	16%	116	4	3%

[a]Maximum value.
[b]Growing season is from April 1 to October 31.
Note – Wyoming data are evaluated using proposed standards for Montana.

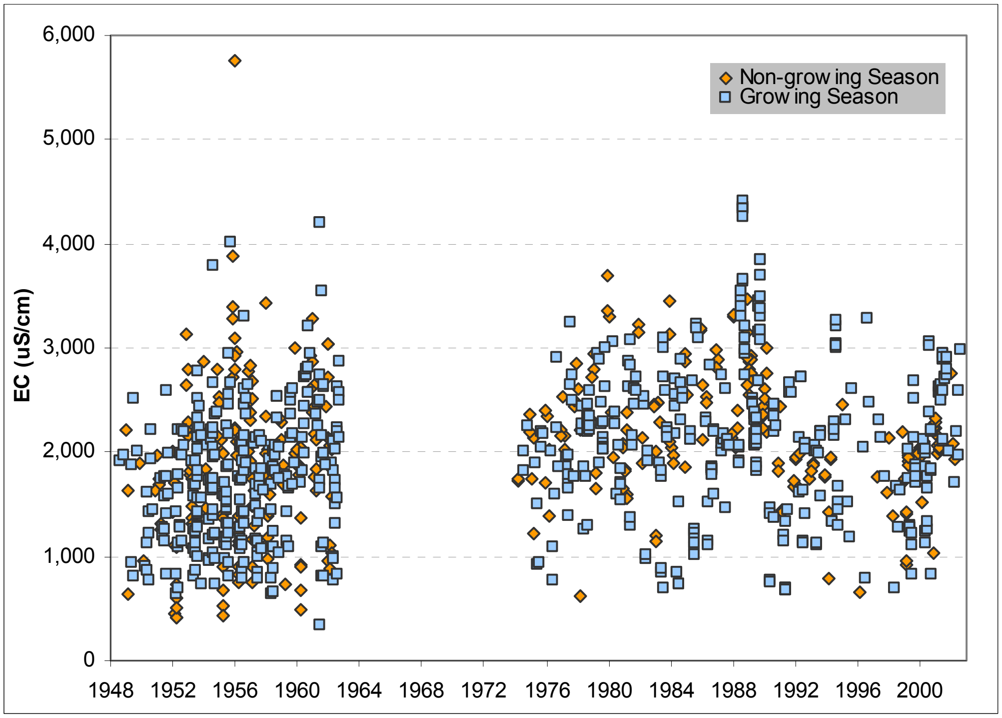

Figure 3-3. EC data for the lower Powder River (all stations).

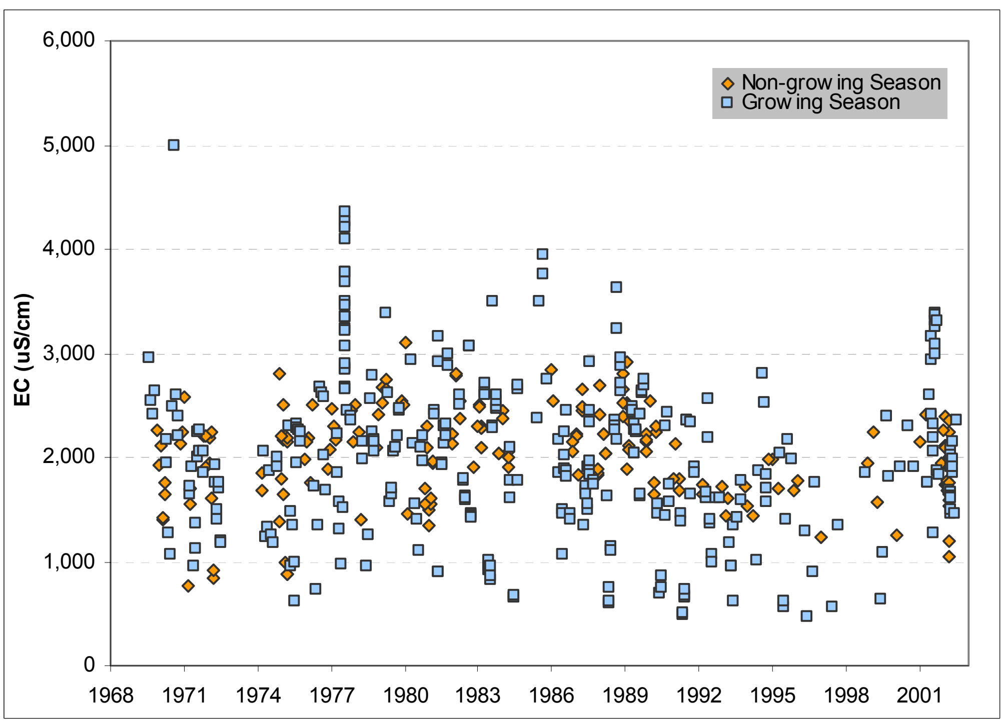

Figure 3-4. EC data for the upper Powder River (all stations).

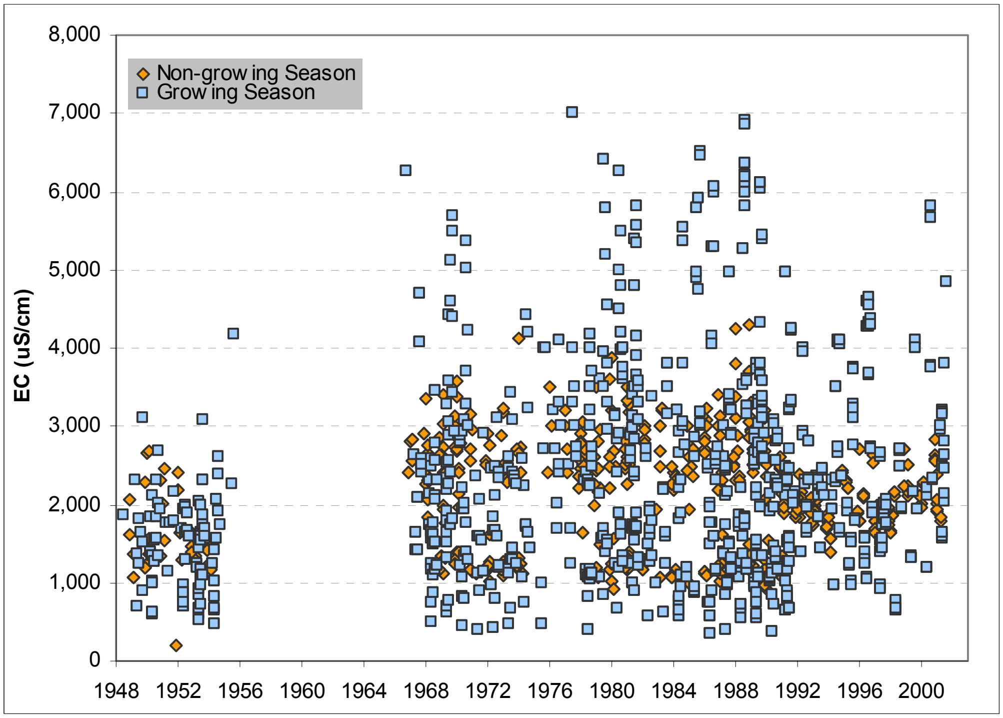

Figure 3-5. EC data for the Powder River in Wyoming (all stations).

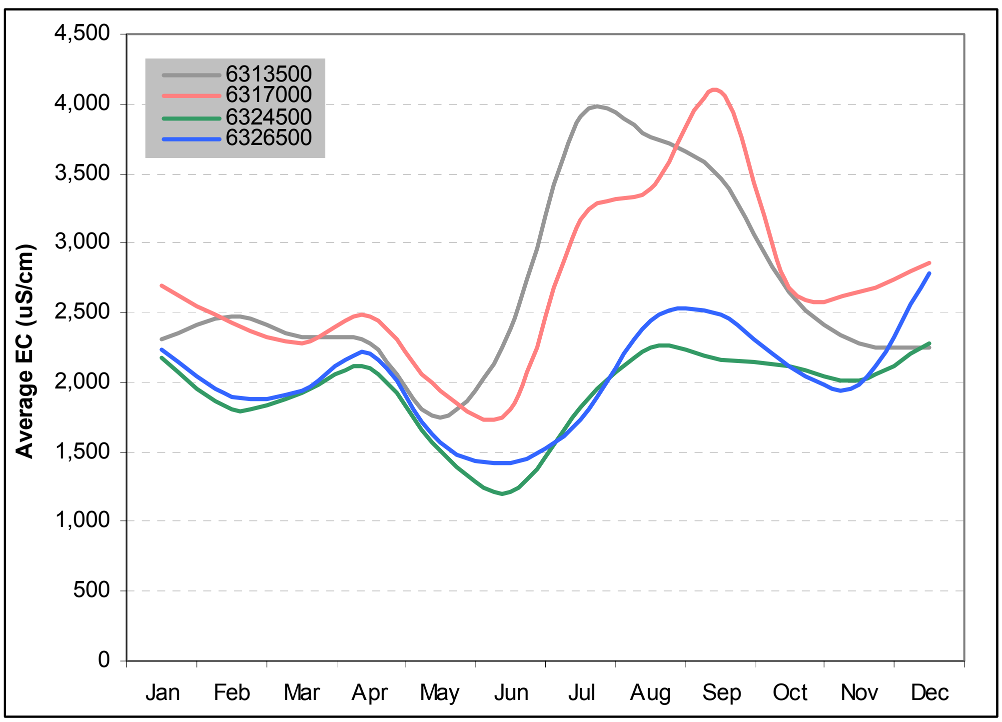

Figure 3-6. Average monthly EC values at four Powder River stations (1970–2000).

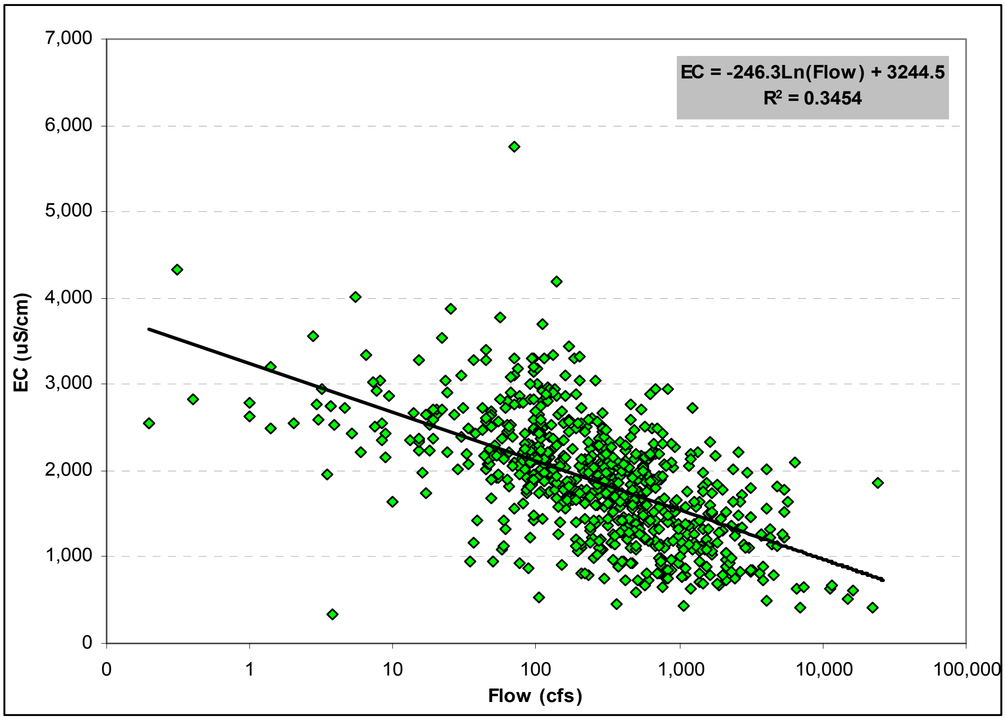

Figure 3-7. Relationship between EC and flow at station 6326500.

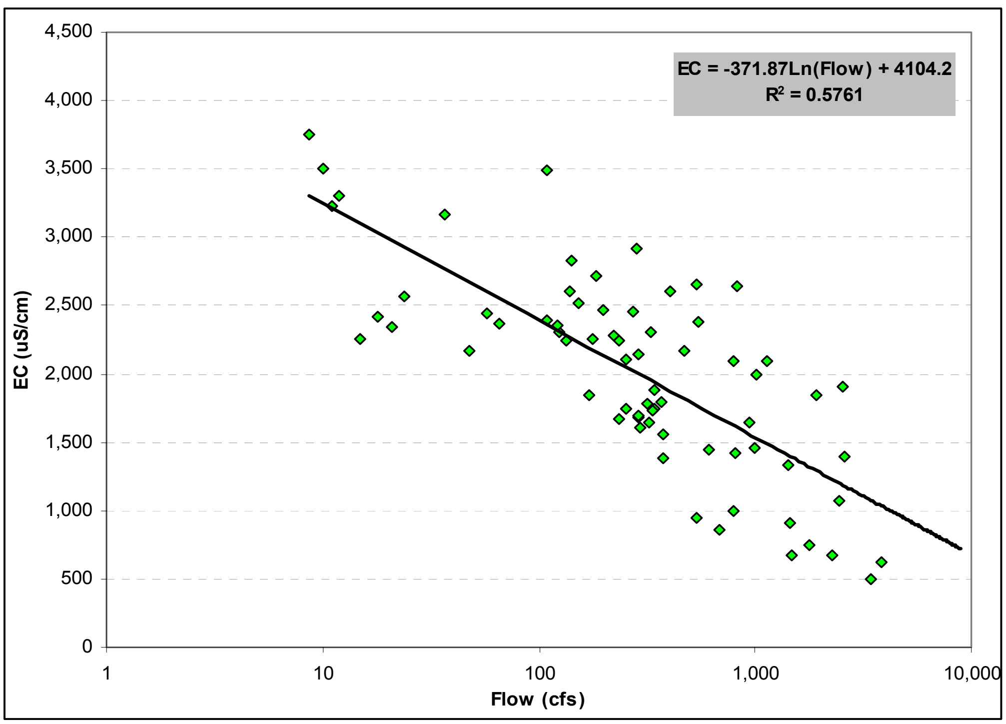

Figure 3-8. Relationship between EC and flow at station 6324710.

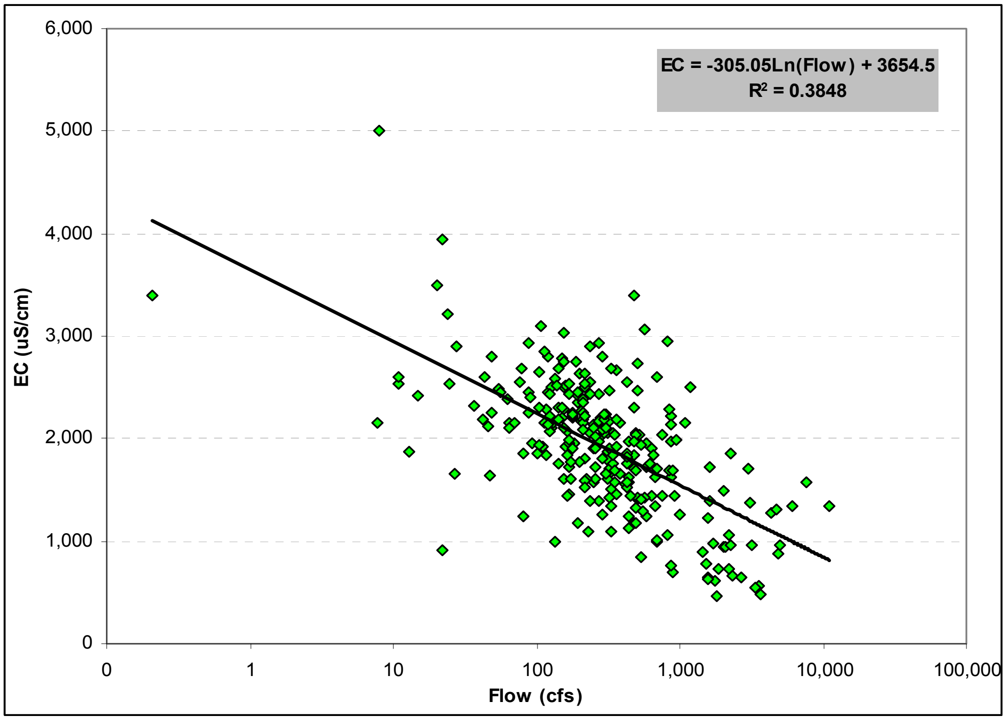

Figure 3-9. Relationship between EC and flow at station 6324500.

3.4.1.3.2 Total Dissolved Solids

As described in Section 3.4.1, the lower Powder River was listed as impaired for total dissolved solids (TDS) on the 1996 303(d) list. Agricultural uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and TDS was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to TDS.

Section 3.4.1.3.1 described salinity (measured as EC) in the Powder River. EC is an indirect measurement of TDS and salinity. The relationship between TDS and EC is different for each waterbody, and it varies with the type of ions in solution, temperature, and barometric pressure. Figure 3-10 shows the relationship between EC and TDS in the lower Powder River. This graph shows EC and TDS data obtained on the same date and location, and it confirms the strong relationship between EC and TDS. The relationship between the two parameters is EC = 1.28(TDS). Therefore, an EC standard of 1,900 µS/cm is equivalent to a TDS concentration of 1,484 mg/L and an EC of 2,000 µS/cm is equivalent to 1,563 mg/L. At station 06326500, the major ions measured by TDS were on average sulfate (51 percent), sodium (15 percent), calcium (10 percent), chloride (5 percent), and magnesium (4 percent). The relationship between EC and TDS in the upper Powder River is EC = 1.34(TDS) (Figure 3-11). Using this equation, an EC standard of 1,900 µS/cm is equivalent to a TDS concentration of 1,417 mg/L and an EC of 2,000 µS/cm is equivalent to 1,493 mg/L.

TDS data for the growing and non-growing seasons are summarized in Tables 3-17 and 3-18. Average values during the growing season regularly exceeded the calculated TDS targets. TDS concentrations for the lower, upper, and Wyoming segments of the Powder River are shown in Figures 3-12 through 3-14. There is no apparent trend in the TDS data over time.

A final water quality impairment determination will not be made for TDS until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2).

Table 3-17. Summary of TDS, Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	1	1,254	1,254	1,254	NA	2/22/74	2/22/74
6326500	294	1,533	278	5,430	40%	12/21/48	2/21/02
Upper Powder							
203	1	1,365	1,365	1,365	NA	2/22/74	2/22/74
6317000	334	1,821	938	2,950	19%	11/3/48	3/16/95
6324500	58	1,386	584	2,200	23%	11/26/69	2/21/02
Wyoming							
6312500	228	866	594	1,270	14%	3/2/49	2/19/87
6313500	152	1,752	1,100	3,850	24%	11/15/66	3/16/95
6313605	2	1,610	1,350	1,870	23%	11/16/00	1/10/01
6313665	2	5	5	5	0%	1/11/89	1/11/89
6317000	334	1,821	938	2,950	19%	11/3/48	3/16/95

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-18. Summary of TDS, Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	9	1,843	1,262	2,451	20%	5/20/77	10/27/01
6326000	8	1,844	1,600	2,280	14%	9/1/78	10/28/01
6326500	471	1,419	322	3,780	38%	8/31/48	10/28/01
6326520	7	1,764	1,540	2,260	14%	9/1/78	10/28/01
Upper Powder							
373	1	2,609	2,609	2,609	NA	7/21/77	7/21/77
530	4	2,153	1,230	2,780	31%	7/22/77	8/18/01
6324500	98	1,547	570	4,080	39%	7/22/69	10/27/01
6324710	20	1,833	462	3,110	37%	4/16/75	10/27/01
Wyoming							
6312500	448	845	233	2,180	42%	5/4/46	9/22/87
6313500	224	2,027	464	4,340	45%	10/11/66	9/28/95
6313605	4	2,303	1,150	3,640	45%	5/8/01	8/14/01
6313665	8	1,973	1,720	2,350	14%	8/31/78	10/17/78
6317000	534	1,909	509	4,780	41%	5/3/46	7/17/01

[a]CV – Coefficient of Variation (standard deviation/mean).

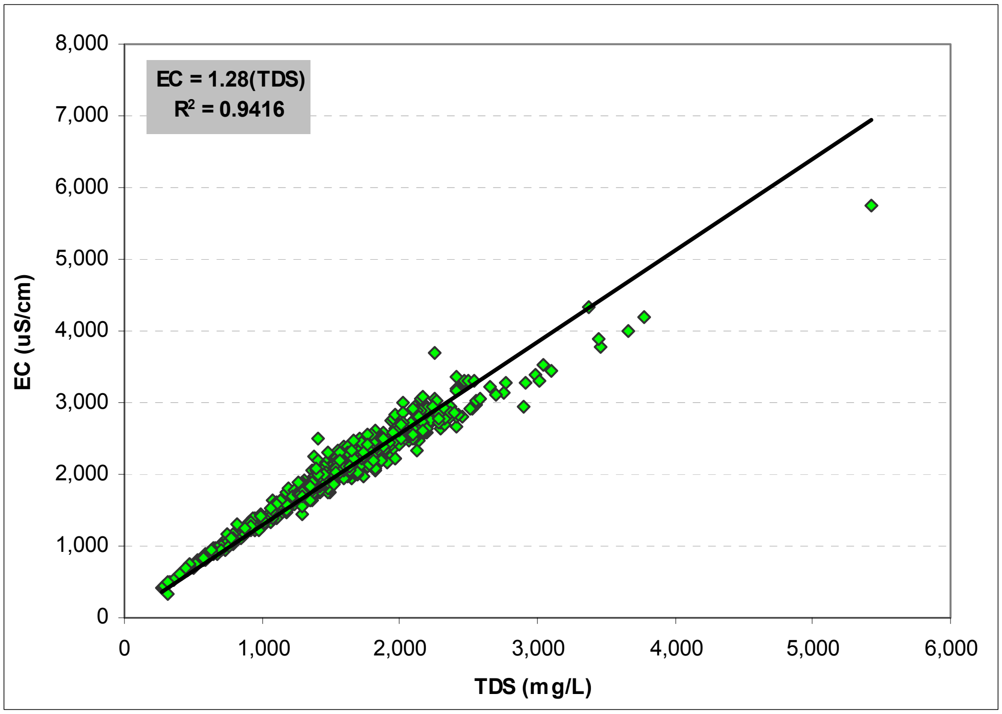

Figure 3-10. Relationship between EC and TDS in the lower Powder River.

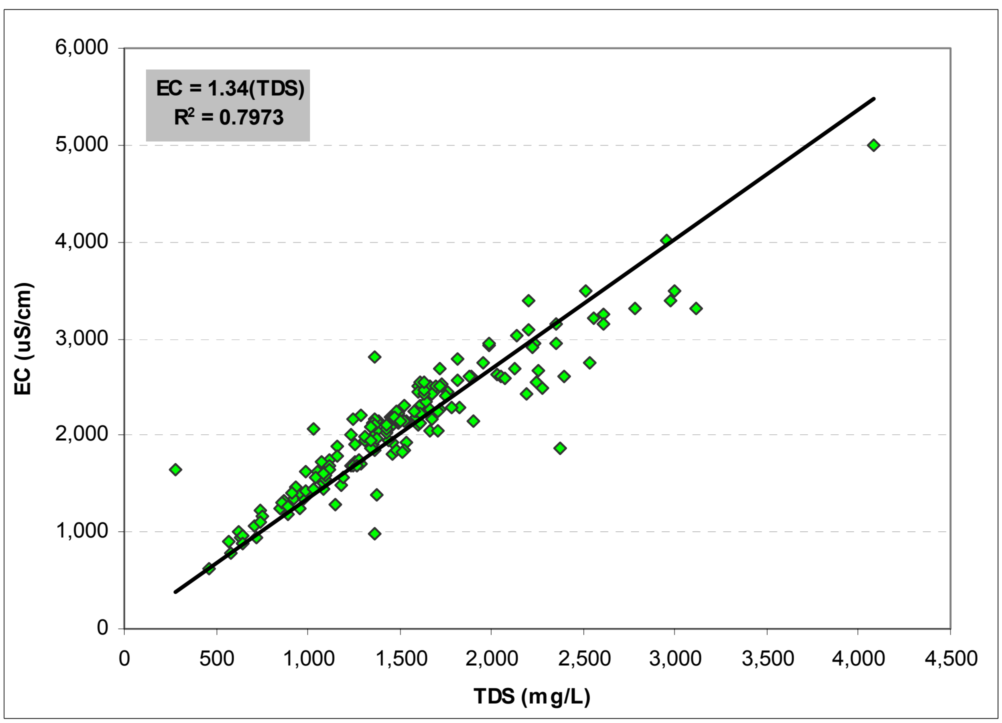

Figure 3-11. Relationship between EC and TDS in the upper Powder River.

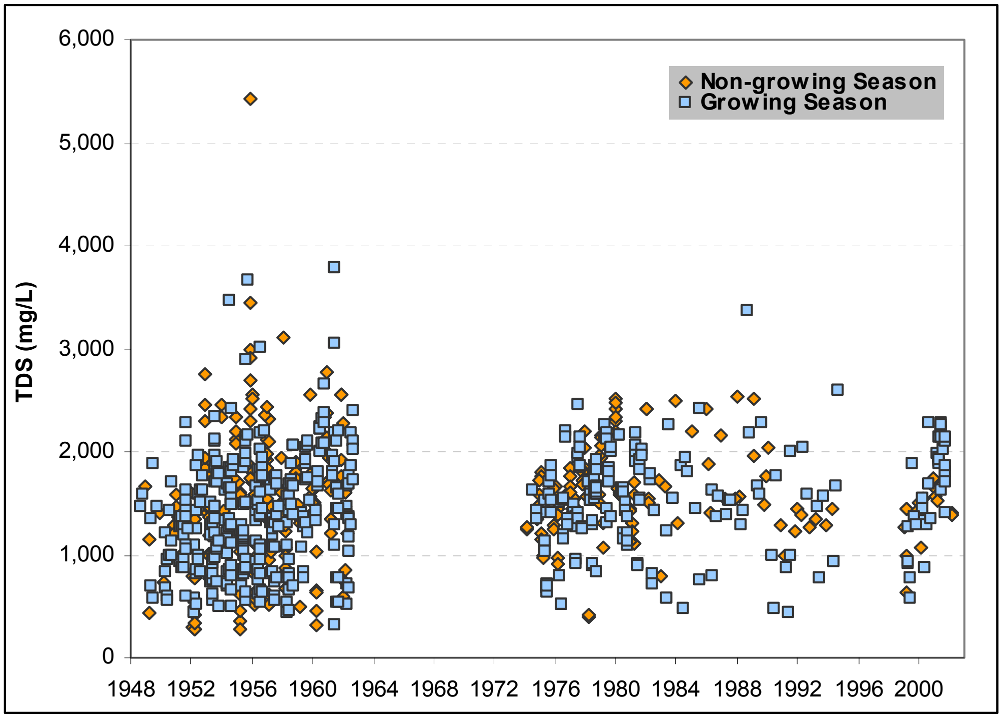

Figure 3-12. TDS data for the lower Powder River (all stations).

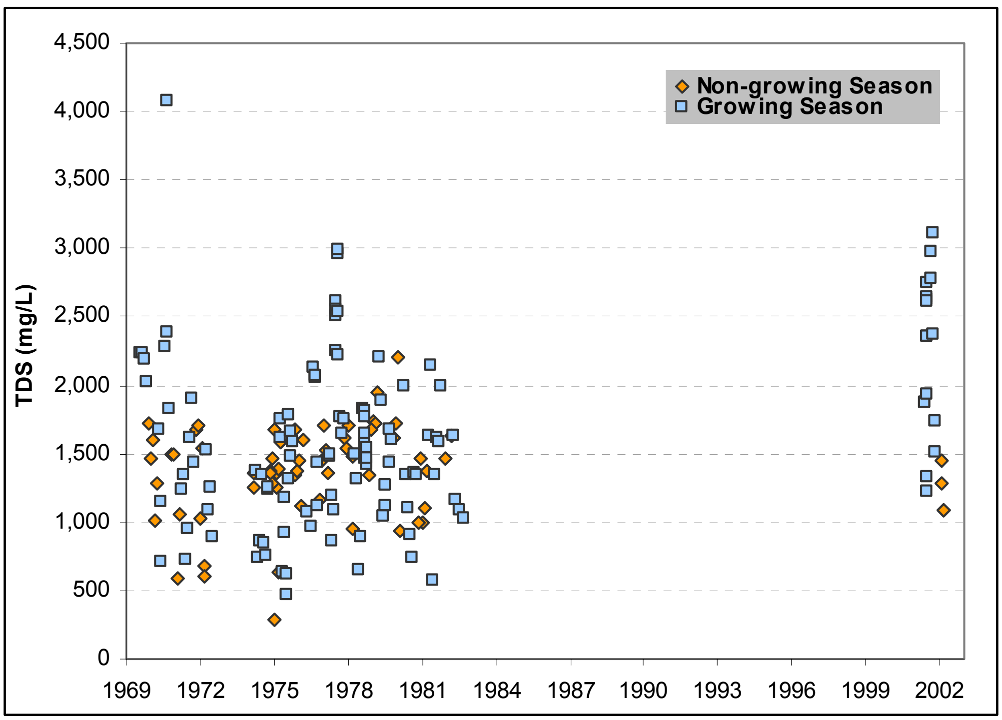

Figure 3-13. TDS data for the upper Powder River (all stations).

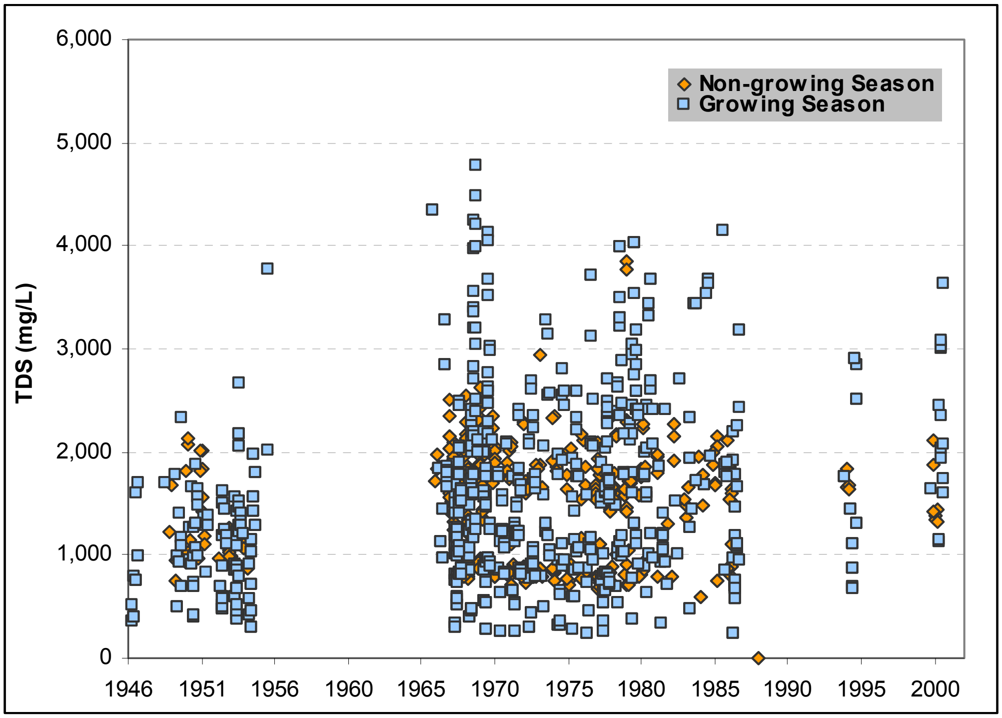

Figure 3-14. TDS data for the Powder River in Wyoming (all stations).

3.4.1.3.3 Chlorides

As described in Section 3.4.1, the lower Powder River was listed as impaired for chlorides on the 1996 303(d) list. Agricultural, aquatic life, and fishery uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and chloride was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to chlorides.

USEPA recommended chloride standards for streams and rivers based on the aquatic toxicity of plant, fish, and invertebrate species (USEPA, 1999). USEPA recommends an acute standard of 860 mg/L and a chronic standard of 230 mg/L. These standards were adopted by Wyoming. Montana does not have numeric standards for chlorides.

Chloride data in the Powder River are summarized in Tables 3-19 and 3-20. Average concentrations were generally less than the EPA proposed standards. Figures 3-15 through 3-17 show all of the chloride data for the Powder River. Figure 3-18 shows that there appeared to be an increase in chloride concentrations in the early 1970s. The average concentration at USGS station 06326500 (Locate) from 1948 to 1962 was 35 mg/L. This increased to 138 mg/L for the period 1972 to 1990 and concentrations then decreased in the early 1990s. The average concentration from 1991 to 2002 was 71 mg/L. The three groups of chloride data were significantly different (p=0.0001) using the Kruskal-Wallis test. USGS attributed the chloride decrease in the 1990s at upstream stations to changes in oil-field discharge practices in Wyoming (USGS, 2001). Overall, there appears to be a slight increasing trend in chloride concentrations in the lower Powder River.

A final water quality impairment determination will not be made for chlorides until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2). Chlorides do not appear to be impairing aquatic life uses in the Powder River.

Table 3-19. Summary of chloride data, Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	5	210	112	280	31%	2/22/74	11/7/89
6326500	151	98	2	340	74%	12/21/48	2/21/02
Upper Powder							
203	1	133	133	133	NA	2/22/74	2/22/74
6324500	70	169	10	330	34%	11/17/70	2/21/02
6324710	9	126	8	240	56%	2/21/74	1/16/02
Wyoming							
6312500	214	51	6	82	21%	3/2/49	1/7/91
6313500	180	230	5	510	48%	11/15/66	2/2/00
6313605	2	188	168	208	15%	11/16/00	1/10/01
6313665	8	348	280	460	21%	11/28/88	11/2/89
6317000	292	242	29	510	42%	11/3/48	1/5/00

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-20. Summary of chloride data, Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	16	182	2	500	64%	8/8/74	10/27/01
6326000	9	133	83	270	43%	9/1/78	10/28/01
6326500	274	63	1	320	92%	8/31/48	10/28/01
6326520	8	130	58	230	38%	9/1/78	10/28/01
Upper Powder							
373	1	217	217	217	NA	7/21/77	7/21/77
530	4	125	64	159	34%	7/22/77	8/18/01
6324500	118	135	0	420	62%	7/23/70	10/27/01
6324710	26	146	8	340	54%	4/16/75	10/27/01
Wyoming							
6312500	500	52	6	227	64%	5/4/46	7/23/91
6313500	294	343	1	1,600	95%	10/11/66	8/16/00
6313605	4	219	65	475	83%	5/8/01	8/14/01
6313665	20	612	170	1,200	59%	8/31/78	9/22/89
6317000	476	226	4	1,300	84%	5/3/46	7/17/01

[a]CV – Coefficient of Variation (standard deviation/mean).

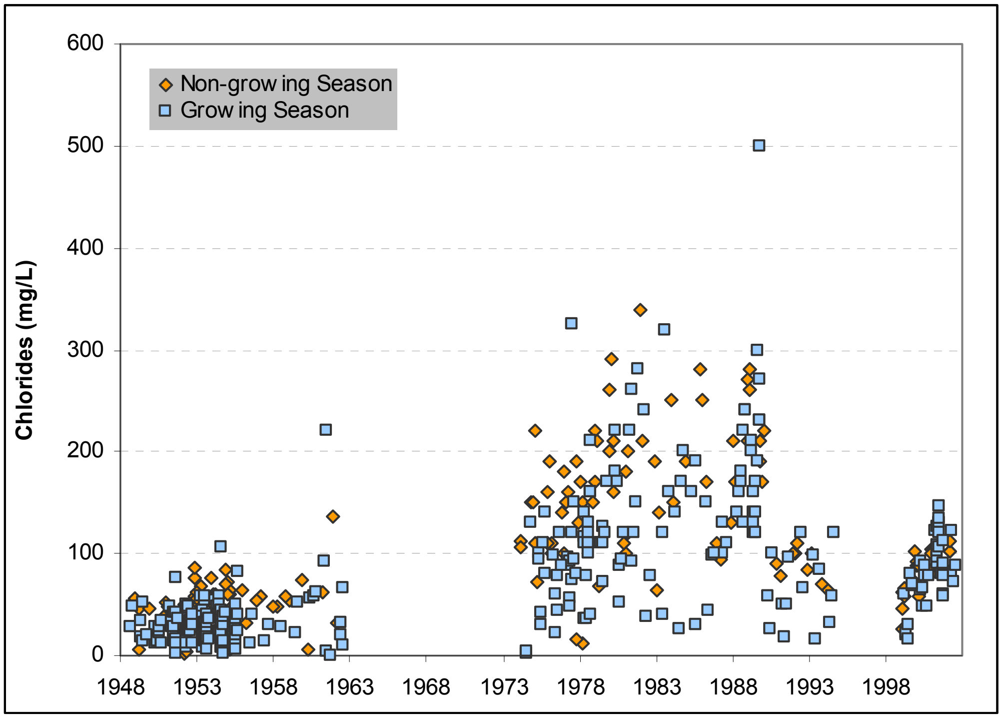

Figure 3-15. Chloride data for the lower Powder River (all stations).

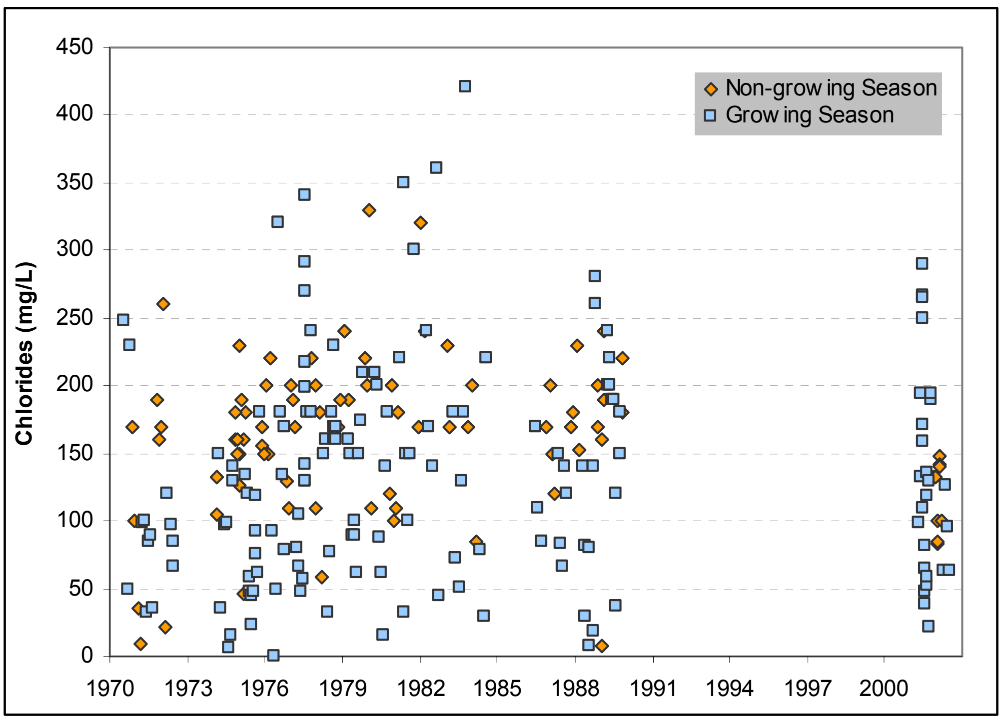

Figure 3-16. Chloride data for the upper Powder River (all stations).

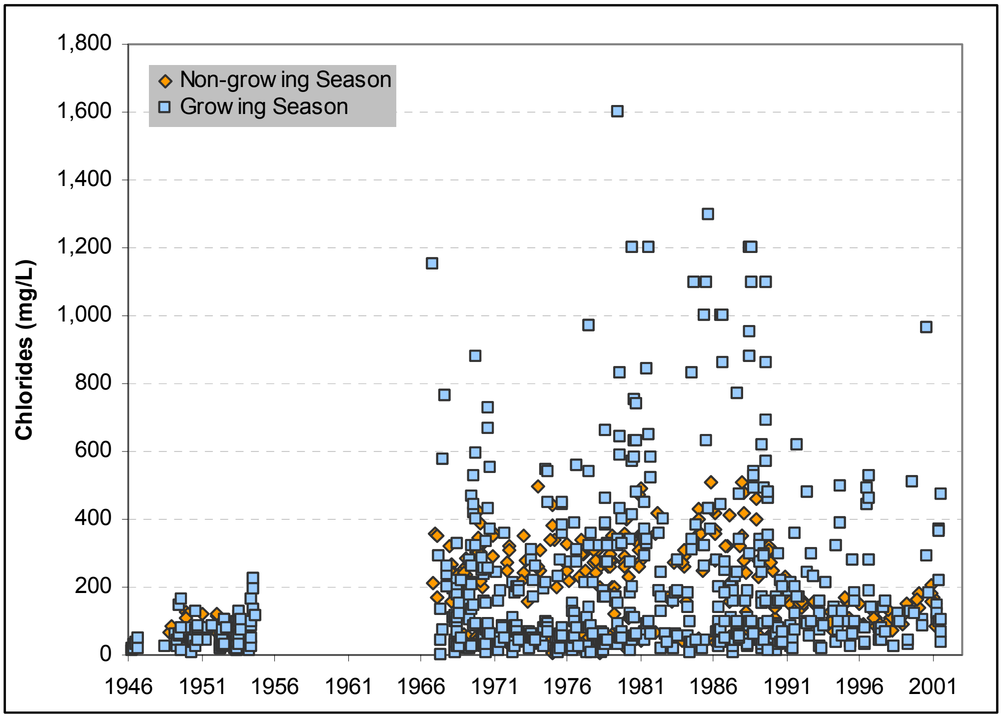

Figure 3-17. Chloride data for the Powder River in Wyoming (all stations).

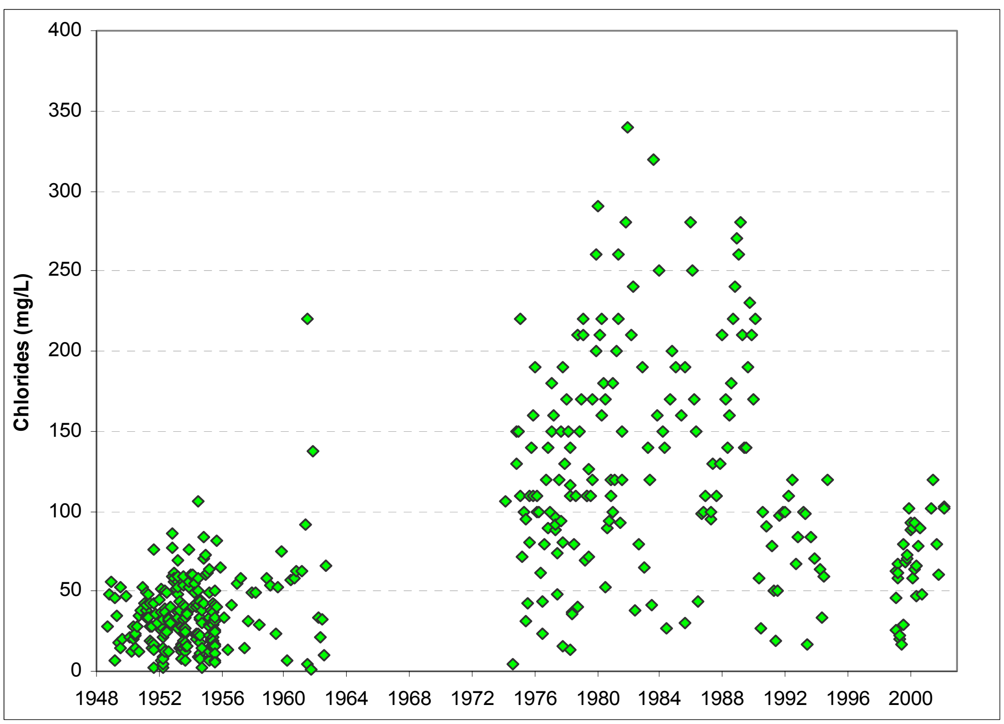

Figure 3-18. Chloride data for station 06326500.

3.4.1.3.4 SAR

The Powder River was not listed as impaired for SAR on the 1996 303(d) list. Agricultural uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and SAR was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to TDS.

Table 3-21 summarizes SAR data at stations on the Powder River. Average concentrations were generally high and most exceeded the maximum SAR criterion of 5. Tables 3-22 through 3-24 compare SAR data to proposed standards. Over 60 percent of samples in the lower and upper Powder River exceeded MDEQ's proposed SAR criteria. Figure 3-19 shows that SAR values in the lower Powder River appear to have a weak increasing trend over time. An increasing trend was not evident in the upper Powder River (Figure 3-20). At station 06317000, there appears to be a decrease in SAR values that could be attributed to changes in oil-field surface water discharges in the early 1990s (USGS, 2001) (Figure 3-21). There is little difference between SAR in the upper and lower Powder River. This is further illustrated by the average monthly concentrations in Figure 3-22. Weak relationships between SAR and flow were found at stations 06326500 in the lower Powder River and at station 06317000 in Wyoming. The relationships suggest that SAR values are lower during periods of high flow. A relationship between SAR and flow in the upper Powder River was not evident (Figures 3-23 through 3-25).

A final water quality impairment determination will not be made for SAR until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-21. Summary of SAR data, Powder River.

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	21	6.6	3.6	10.9	30%	2/22/74	10/27/01
6326000	9	6.4	4.9	8.7	22%	9/1/78	10/28/01
6326500	336	4.3	0.6	11.6	39%	10/3/50	2/21/02
6326520	8	6.4	5.1	8.6	21%	9/1/78	10/28/01
Upper Powder							
203	1	4.5	4.5	4.5	NA	2/22/74	2/22/74
373	1	6.4	6.4	6.4	NA	7/21/77	7/21/77
530	4	5.2	3.9	5.9	17%	7/22/77	8/18/01
6324500	172	4.6	0.1	8.9	33%	7/23/70	2/21/02
6324710	35	5.3	1.8	15.1	43%	2/21/74	1/16/02
Wyoming							
6312500	208	2.0	0.5	4.8	0.4	4/27/52	7/23/91
6313500	184	7.6	1.8	40.4	0.7	10/11/66	8/16/00
6313605	6	6.5	4.2	11.3	0.4	11/16/00	8/14/01
6313665	14	14.6	5.9	35.0	0.6	8/31/78	11/2/89
6317000	325	6.3	1.3	27.5	0.5	5/13/53	7/12/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-22. Summary of SAR exceedances, lower Powder River.

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
***MDEQ*[a]**							
All Seasons	Variable[1]	374	151	40%	42	13	31%
Petitioners (Powder River at the Mouth)							
April 15–July 15	4.0	110	51	46%	16	11	69%
July 16–Sept 1	5.0	65	27	42%	2	2	100%
Non irrigation Season	6.0	199	38	19%	23	2	9%

[a]Reported data are from sample dates with both an SAR and salinity measurement, and criteria are based on the formula SAR <= (EC * 0.0071) – 2.475.

Table 3-23. Summary of SAR exceedances, upper Powder River.

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
***MDEQ*[a]**							
All Seasons	Variable[1]	213	88	41%	20	11	55%
Petitioners (Powder River at Moorhead, MT)							
April 15–July 15	4.0	57	31	54%	8	8	100%
July 16– Sept 1	5.0	36	16	44%	5	3	60%
Non irrigation Season	6.0	120	18	15%	7	0	0%

[a]Reported data are from sample dates with both an SAR and salinity measurement, and criteria are based on the formula SAR <= (EC * 0.0071) – 2.475.

Table 3-24. Summary of SAR exceedances, Wyoming USGS station 06317000.

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
***MDEQ*[a]**							
All Seasons	Variable[1]	737	365	50%	68	24	35%
Petitioners (Powder River at Moorhead, MT)							
April 15–July 15	4.0	221	90	41%	20	11	55%
July 16– Sept 1	5.0	111	63	57%	12	8	67%
Non irrigation Season	6.0	405	173	43%	36	3	8%

[a]Reported data are from sample dates with both an SAR and salinity measurement, and criteria are based on the formula SAR <= (EC * 0.0071) – 2.475.

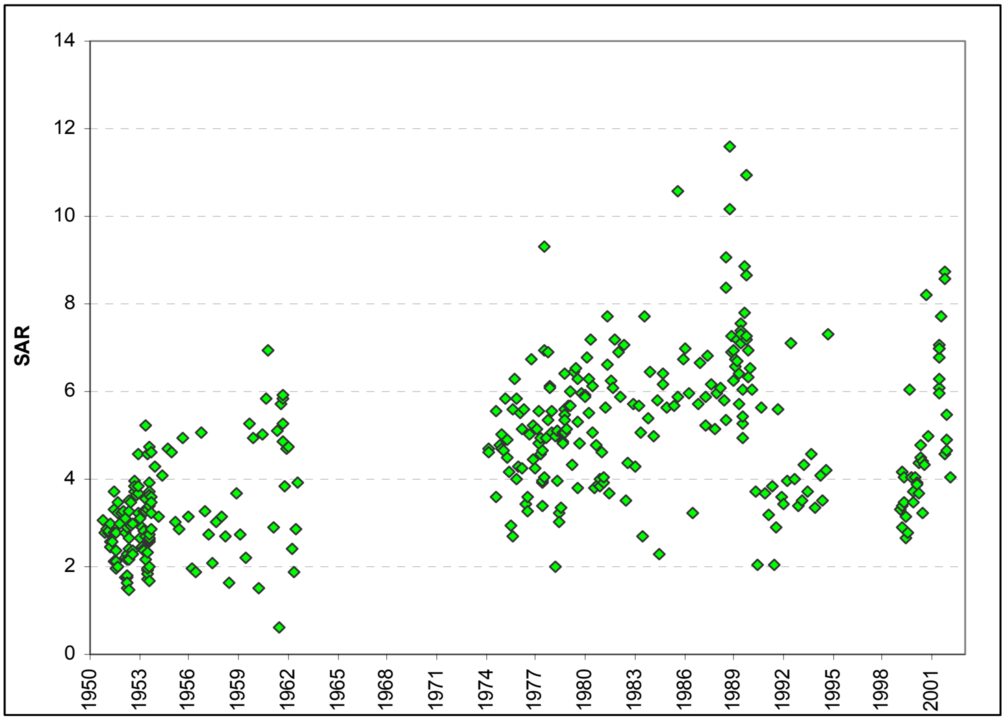

Figure 3-19. SAR data in the lower Powder River (all stations).

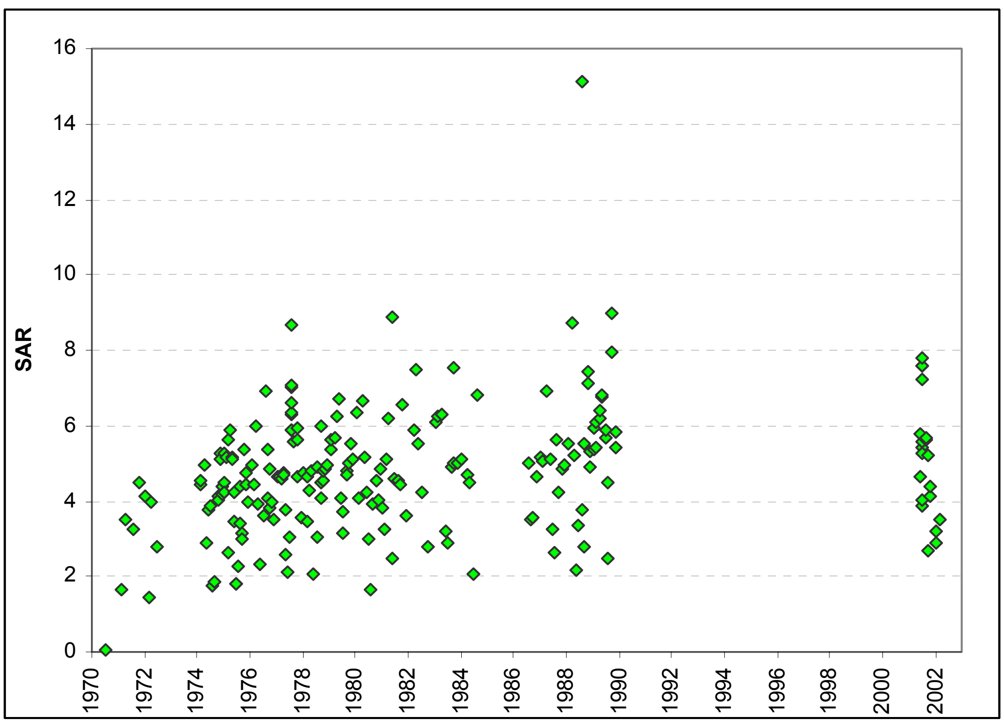

Figure 3-20. SAR data in the upper Powder River (all stations).

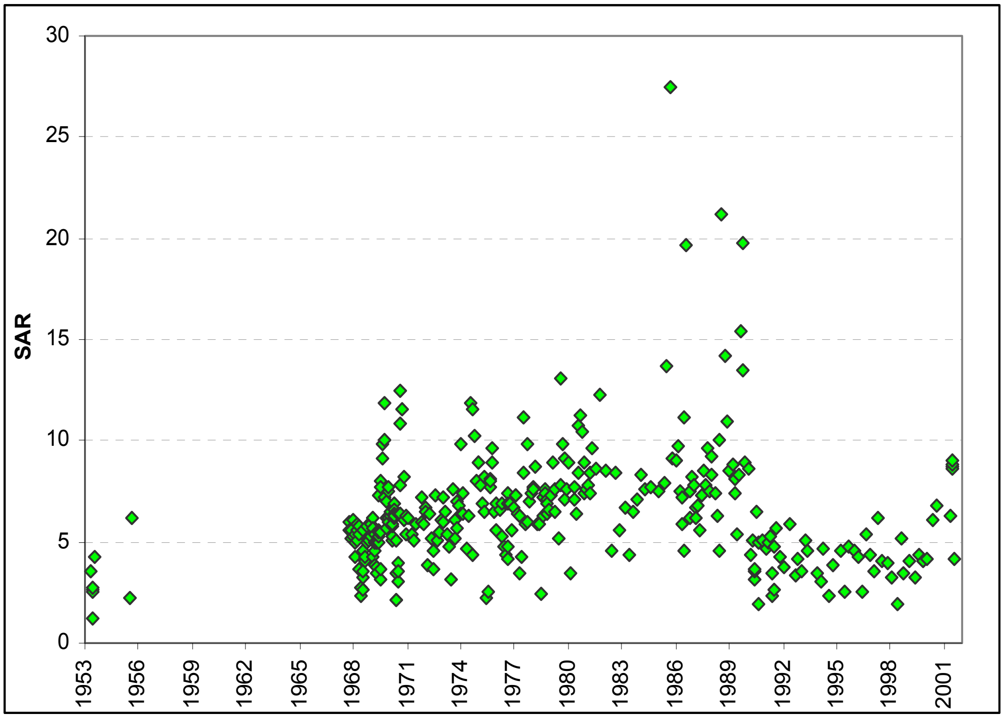

Figure 3-21. SAR data at USGS gage 06317000 in Wyoming.

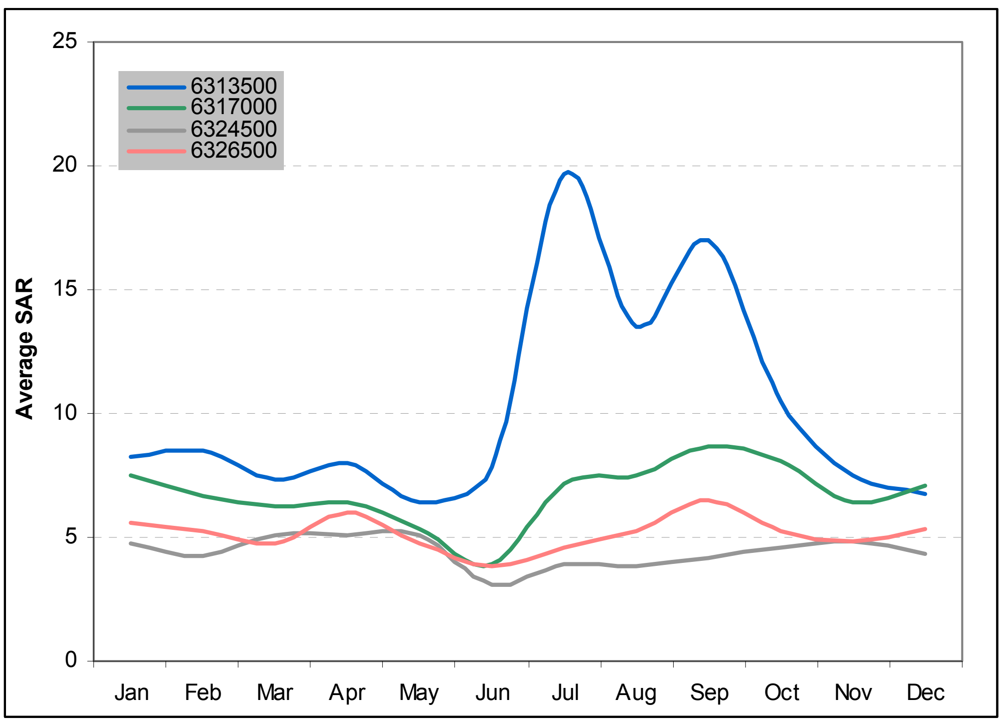

Figure 3-22. Average SAR per month at four USGS stations in the Powder River (1970-2000).

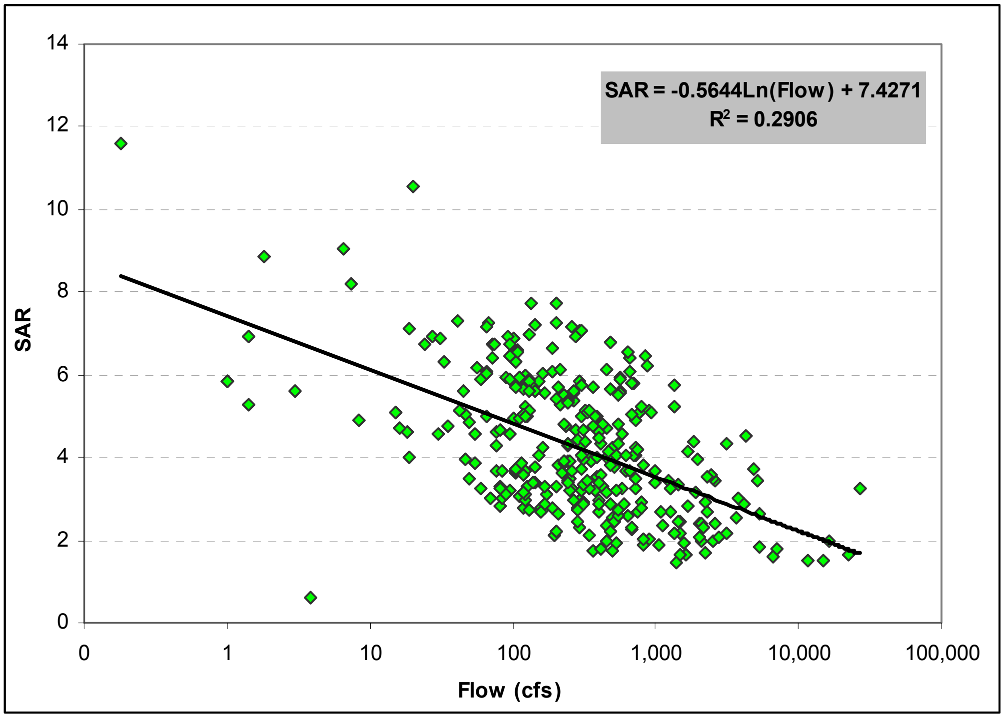

Figure 3-23. Relationship between SAR and flow at station 06326500.

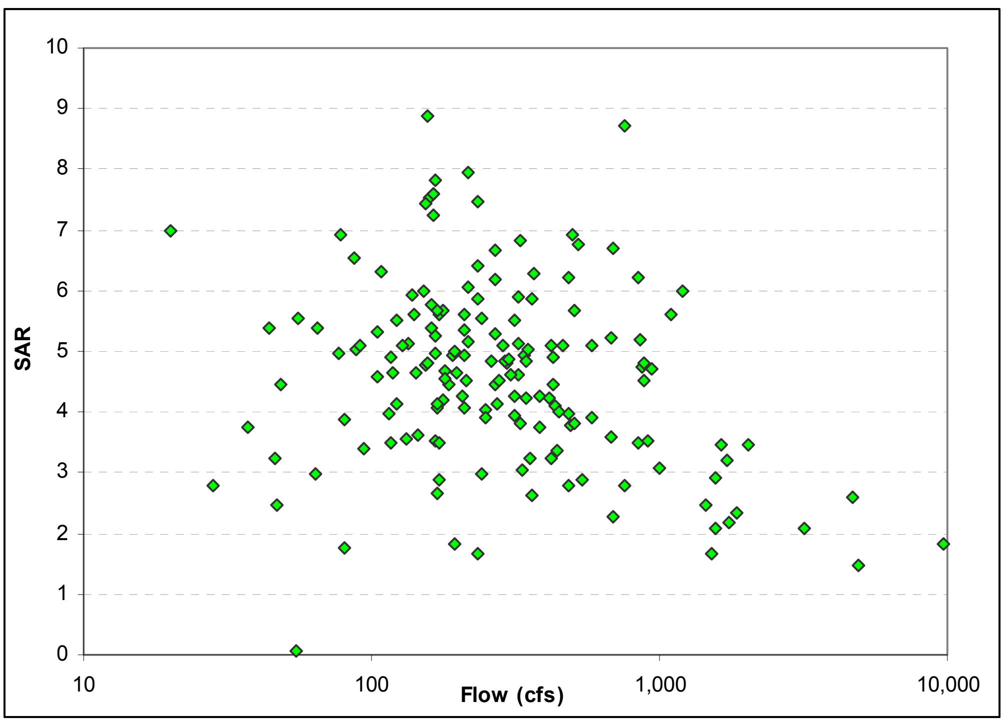

Figure 3-24. Relationship between SAR and flow at station 06324500.

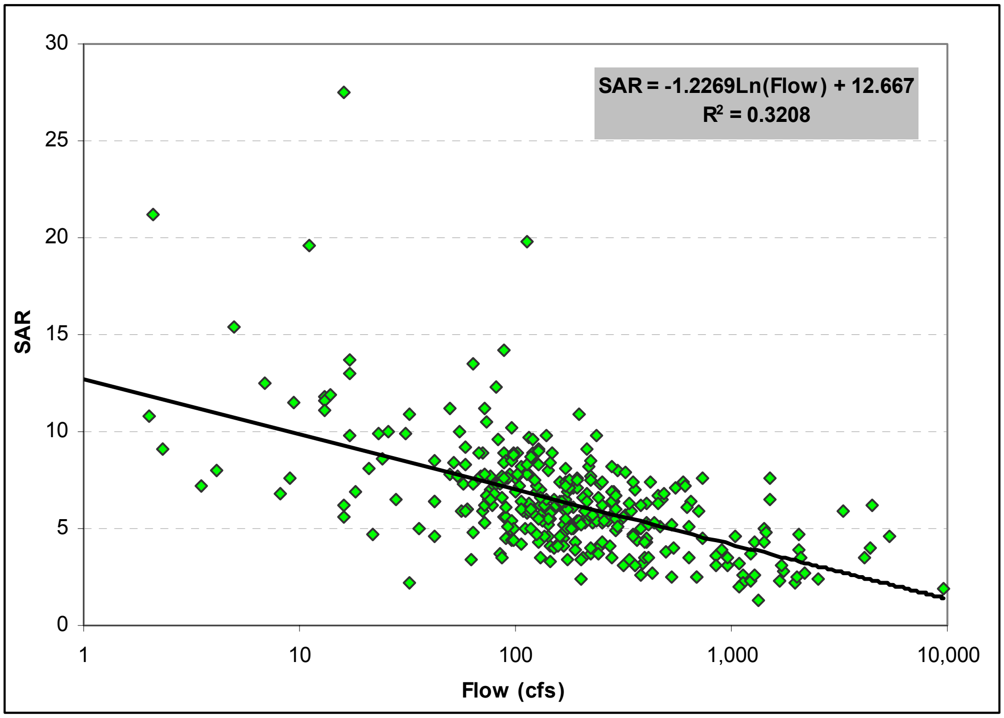

Figure 3-25. Relationship between SAR and flow at station 06317000.

3.4.1.3.5 Other Inorganics (Sulfate)

As described in Section 3.4.1, the lower Powder River was listed as impaired for other inorganics (sulfates) on the 1996 303(d) list. Agricultural uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and sulfate was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to sulfates. EPA has a sulfate secondary drinking water standard of 250 mg/L. Several states (North Dakota, New Mexico, South Dakota, Utah) have chosen statewide or site-specific sulfate standards of 250, 500, or 750 mg/L.

As stated in Section 3.4.1.3.2, surrogate TDS targets for the lower Powder River are 1,484 mg/L (April 1–October 31) and 1,563 mg/L (November 1–March 31). The TDS targets for the upper Powder River are 1,417 mg/L and 1,493 mg/L for the growing season and non-growing season, respectively. These targets were used to help determine sulfate impairments in the Powder River because TDS is partially composed of sulfates. By definition, the dissolved sulfate concentration in a stream must be equal to or less than the TDS concentration. At station 06326500, sulfates were on average 51 percent of the TDS in the river.

Tables 3-25 and 3-26 summarize the sulfate data for the Powder River. Sulfate concentrations were generally much higher than the secondary drinking water standard of 250 mg/L. Several samples exceeded the calculated TDS targets in all three segments of the Powder River (Figures 3-26 through 3-28).

A final water quality impairment determination will not be made for sulfate until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2).

Table 3-25. Summary of sulfate data, Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	15	1,048	660	1,700	29%	5/20/77	10/27/01
6326000	9	977	750	1,300	19%	9/1/78	10/28/01
6326500	376	756	33	2,210	46%	8/31/48	7/23/02
6326520	8	981	780	1,300	21%	9/1/78	10/28/01
Upper Powder							
373	1	1,362	1,362	1,362	NA	7/21/77	7/21/77
530	4	1,162	662	1,510	31%	7/22/77	8/18/01
6324500	134	740	140	1,770	43%	7/22/69	7/10/02
6324710	26	940	193	1,750	38%	4/16/75	10/27/01
Wyoming							
6312500	492	378	78	1,310	47%	5/4/46	7/23/91
6313500	294	745	140	1,600	43%	10/11/66	8/16/00
6313605	4	1,136	493	1,670	43%	5/8/01	8/14/01
6313665	20	808	290	1,200	34%	8/31/78	9/22/89
6317000	246	911	203	2,580	40%	5/3/46	7/17/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-26. Summary of sulfate data, Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	5	745	513	870	19%	2/22/74	11/7/89
6326500	220	765	103	2,830	45%	12/21/48	3/25/02
Upper Powder							
203	1	560	560	560	NA	2/22/74	2/22/74
6324500	78	635	280	1,000	21%	11/26/69	3/19/02
6324710	9	617	260	820	27%	2/21/74	1/16/02
Wyoming							
6312500	214	391	270	585	16%	3/2/49	1/7/91
6313500	180	657	370	2,300	36%	11/15/66	2/2/00
6313605	2	663	528	797	29%	11/16/00	1/10/01
6313665	8	660	480	830	20%	11/28/88	11/2/89
6317000	151	769	390	1,160	20%	11/3/48	3/13/01

[a]CV – Coefficient of Variation (standard deviation/mean).

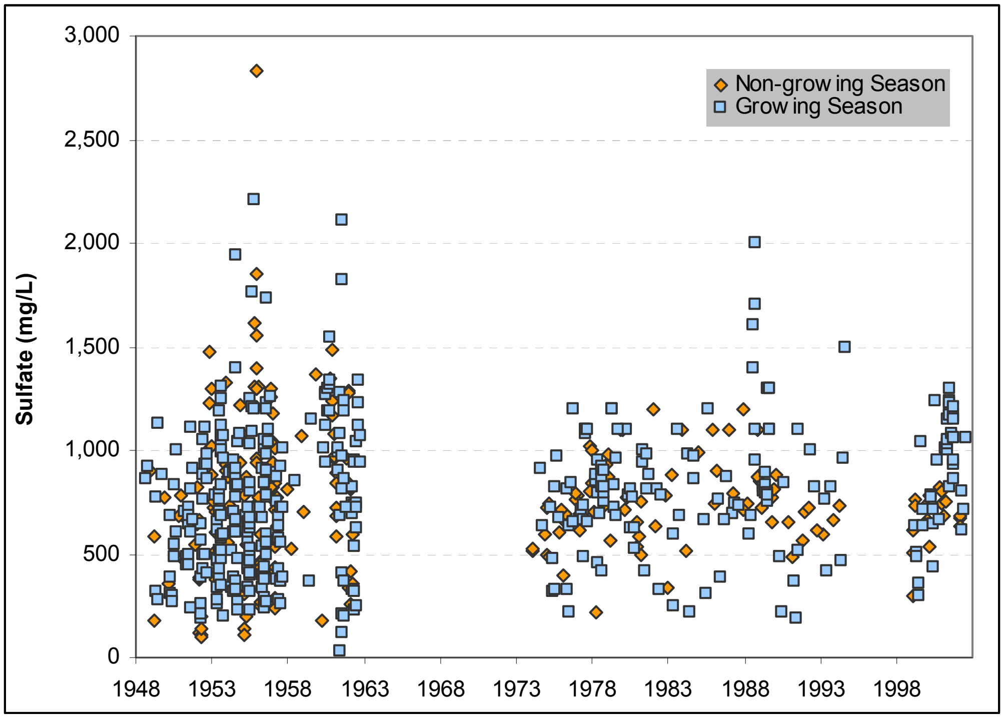

Figure 3-26. Sulfate data for the lower Powder River (all stations).

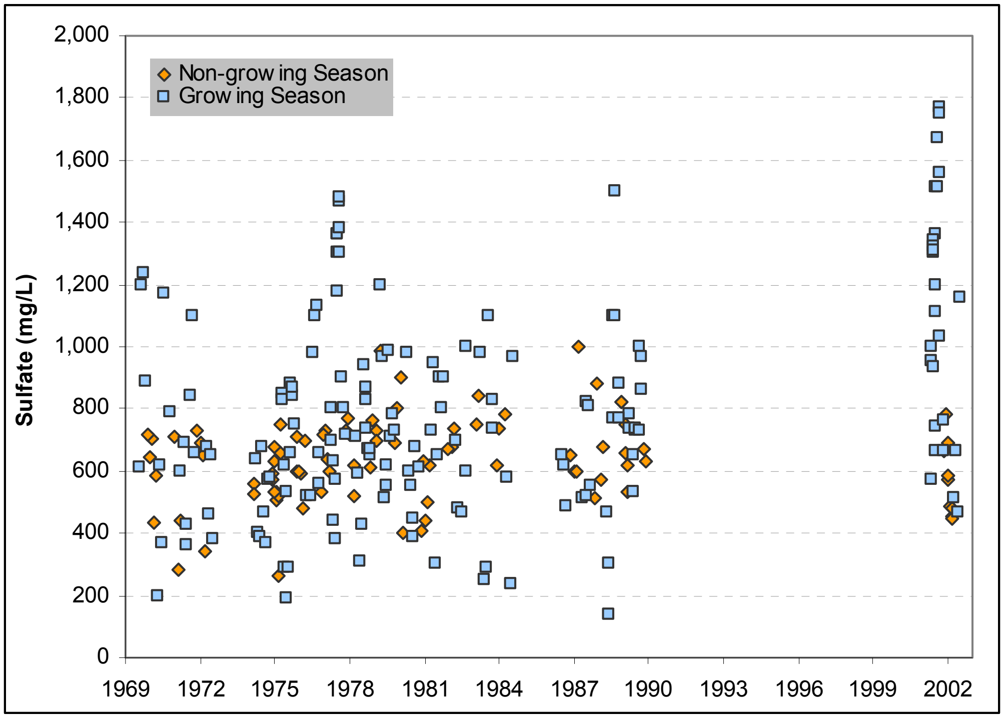

Figure 3-27. Sulfate data for the upper Powder River (all stations).

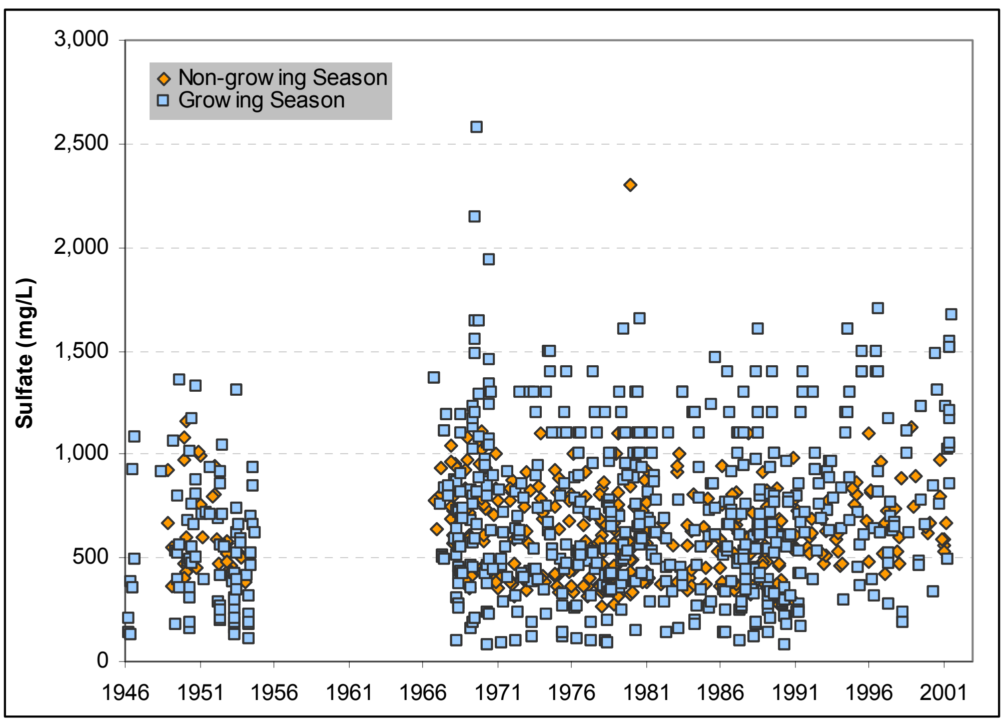

Figure 3-28. Sulfate data for the Powder River in Wyoming (all stations).

3.4.1.3.6 Metals

As described in Section 3.4.1, the lower Powder River was listed as impaired for metals on the 1996 303(d) list. Aquatic life, and fishery uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and metals were not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to metals.

Recent metals sampling was performed at stations in the Powder River from 1999 through 2002. Both total recoverable (TR) and dissolved metals concentrations are available for the lower and upper segments of the Powder River. Montana's numeric metals standards are for TR metals. Dissolved metals concentrations are compared to the calculated standards as described in Section 3.3.1.2. Both chronic and acute metals standards exist for most metals. Acute standards are defined as "No samples shall exceed these concentrations" (MDEQ, 2002). Chronic standards are defined as "No four-day (96-hour) or longer period average concentration shall exceed these values." Criteria shown in the following sections are for determining aquatic life impairments. For this analysis, the chronic standards are compared to individual samples and to 4-year averages (1999-2002).

Tables 3-27 through 3-30 show the metals standards and exceedances for the lower Powder River and upper Powder River. No dissolved metals concentrations exceeded the acute criteria in the lower or upper segments of the Powder River. In the lower Powder River, one selenium sample exceeded the chronic criterion. However, the 4-year average selenium concentration for the lower Powder River was below the chronic standard.

The TR acute standards for cadmium, copper, and zinc were exceeded for both the lower and upper Powder River. In the lower Powder River, two or more cadmium, copper, iron, lead, nickel, and zinc samples exceeded the chronic criteria. Table 3-31 shows that the 4-year average concentrations for TR cadmium, copper, iron, and lead exceeded the chronic criteria in the lower Powder River. Two or more samples of cadmium, copper, iron, and lead exceeded the chronic criteria in the upper Powder River. Single samples of nickel, selenium, and zinc also exceeded the chronic criteria. Four-year average concentrations of cadmium and iron exceeded the chronic criteria in this segment.

The lower and upper segments of the Powder River are impaired because of metals. Cadmium, copper, iron, lead, nickel, and zinc are impairing aquatic life uses in the lower Powder River. Cadmium, copper, iron, lead, and zinc are impairing aquatic life uses in the upper Powder River. This is based on the following information:

- Acute standard exceedances for cadmium, copper, and zinc in the upper and lower segments of the Powder River.
- Two or more samples in the lower Powder River exceeding the chronic standard for cadmium, copper, iron, lead, nickel, and zinc.
- Two or more samples in the upper Powder River exceeding the chronic standard for cadmium, copper, iron, and lead.
- Four-year average concentrations in the lower Powder River exceeding the chronic standard for cadmium, copper, iron, and lead.
- Four-year average concentrations in the upper Powder River exceeding the chronic standard for cadmium and iron.

Table 3-27. Summary of dissolved metals data in the lower Powder River (1996–2002).

Parameter	Total # of Samples	Acute			Chronic		
		Criteria (µg/L)	Total # of Exceedances	Percent Exceeding	Criteria (µg/L)	Total # of Exceedances	Percent Exceeding
Arsenic	27	340	0	0%	150	0	0%
Cadmium	27	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Chromium	26	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Copper	26	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Lead	28	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Nickel	27	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Selenium	31	18.4[a]	0	0%	4.6[a]	1	3%
Silver	27	Variable[a,b]	0	0%	NA	NA	NA
Zinc	26	Variable[a,b]	0	0%	Variable[a,b]	0	0%

[a]Criteria were calculated based on the Montana TR metals standards and the EPA conversion factors shown in Appendix F.
[b]Hardness-dependent criteria (hardness as mg/L of $CaCO_3$).

Table 3-28. Summary of TR metals data in the lower Powder River (1996–2002).

Parameter	Total # of Samples	Acute			Chronic		
		Criteria (µg/L)	Total # of Exceedances	Percent Exceeding	Criteria (µg/L)	Total # of Exceedances	Percent Exceeding
Arsenic	20	340	0	0%	150	0	0%
Cadmium	21	Variable[a]	1	5%	Variable[a]	4	19%
Chromium	21	Variable[a]	0	0%	Variable[a]	0	0%
Copper	21	Variable[a]	4	19%	Variable[a]	5	24%
Iron	16	NA	NA	NA	1,000	7	44%
Lead	20	Variable[a]	0	0%	Variable[a]	4	20%
Nickel	20	Variable[a]	0	0%	Variable[a]	2	10%
Selenium	12	20	0	0%	5	2	17%
Silver	4	Variable[a]	0	0%	NA	NA	NA
Zinc	21	Variable[a]	2	10%	Variable[a]	2	10%

[a]Hardness-dependent criteria (hardness as mg/L of $CaCO_3$).

Table 3-29. Summary of dissolved metals data in the upper Powder River (1996–2002).

Parameter	Total # of Samples	Acute Criteria (µg/L)	Acute Total # of Exceedances	Acute Percent Exceeding	Chronic Criteria (µg/L)	Chronic Total # of Exceedances	Chronic Percent Exceeding
Arsenic	12	340	0	0%	150	0	0%
Cadmium	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Chromium	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Copper	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Lead	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Nickel	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%
Selenium	14	18.4[a]	0	0%	4.6[a]	0	0%
Silver	12	Variable[a,b]	0	0%	NA	NA	NA
Zinc	12	Variable[a,b]	0	0%	Variable[a,b]	0	0%

[a]Criteria were calculated based on the Montana TR metals standards and the EPA conversion factors shown in Appendix F.
[b]Hardness-dependent criteria (hardness as mg/L of $CaCO_3$).

Table 3-30. Summary of TR metals data in the upper Powder River (1996–2002).

Parameter	Total # of Samples	Acute Criteria (µg/L)	Acute Total # of Exceedances	Acute Percent Exceeding	Chronic Criteria (µg/L)	Chronic Total # of Exceedances	Chronic Percent Exceeding
Arsenic	16	340	0	0%	150	0	0%
Cadmium	16	Variable[a]	1	6%	Variable[a]	3	19%
Chromium	14	Variable[a]	0	0%	Variable[a]	0	0%
Copper	16	Variable[a]	1	6%	Variable[a]	3	19%
Iron	16	NA	NA	NA	1,000	9	56%
Lead	16	Variable[a]	0	0%	Variable[a]	2	13%
Nickel	16	Variable[a]	0	0%	Variable[a]	1	6%
Selenium	14	20	0	0%	5	1	7%
Silver	2	Variable[a]	0	0%	NA	NA	NA
Zinc	16	Variable[a]	1	6%	Variable[a]	1	6%

[a]Hardness-dependent criteria (hardness as mg/L of $CaCO_3$).

Table 3-31. Average TR metals concentrations, 1999-2002.

	Chronic Criteria[a]		Average Lower Powder River Concentrations		Average Upper Powder River Concentrations	
Parameter	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**
Arsenic	150	150	0.88	7.25	0.93	4.75
Cadmium	0.64	0.76	0.29	1.02	0.02	0.81
Chromium	85	268	0.85	20.78	0.41	13.78
Copper	29	30	4.63	38.36	4.73	19.93
Iron	NA	1,000	NA	19,836	NA	15,884
Lead	11	19	0.34	28.00	0.08	15.25
Nickel	168	169	2.70	42.65	2.40	24.75
Selenium	4.6	5.0	1.73	2.65	2.24	2.51
Zinc	382	388	4.25	112.40	2.83	56.31

[a]Hardness-dependent criteria (hardness as mg/L of $CaCO_3$). A water hardness of 400 mg/L (the maximum allowable hardness) was used to determine the criteria.

3.3.1.3.7 Nutrients

As described in Section 3.4.1, the lower Powder River was listed as impaired for nutrients on the 1996 303(d) list. Aquatic life and fishery uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and nutrients were not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to nutrients.

Few states, including Montana, have numeric nutrient standards. This is because natural concentrations of nutrients vary among streams. Also, aquatic life and stream response to nutrient concentrations vary with different systems. Table 3-32 presents a summary of nutrient standards and guidelines from different states. Included in Table 3-32 are the nutrient standards developed for the Clark Fork River in Montana. Ohio Environmental Protection Agency (OEPA) nutrient guidelines are based on biological response to nutrients and are based on the size of the watershed and type of stream. OEPA standards shown in Table 3-32 are for large rivers (>1,000 square miles) and warmwater habitats.

Table 3-32. Guidelines for nutrient criteria from various states.{tc "Table 11. North Dakota nitrate and total phosphorus guidelines for Class 1 and Class 1A streams. " \f D }

State	Total Nitrogen/Nitrite/Nitrate	Total Phosphorus (P)
Montana (Clark Fork)	0.30 mg/L (Total Nitrogen)	0.039 mg/L
North Dakota	1.0 mg/L (Nitrate)	0.10 mg/L
Ohio	2.0 mg/L (Nitrite/Nitrate)	0.30 mg/L
Utah	4.0 mg/L (Nitrate)	0.05 mg/L

Sources: OEPA, 1999; UDAR, 2002.

A summary of nutrient data in the lower Powder River is presented in Tables 3-33 and 3-34. It should be noted that median total phosphorus (TP) concentrations were often different from average concentrations. This indicates that TP is not normally distributed and also explains the high coefficients of variation. Figure 3-29 shows the TP distribution in the lower Powder River. TP concentrations often exceeded 1 mg/L and concentrations greater than 20 mg/L were recorded. The same pattern was not observed with the nitrite/nitrate data (Figure 3-30).

DO data can be used to help identify nutrient impairments in the Powder River. Excess nutrients in a waterbody can lead to nuisance algal blooms and low DO concentrations. DO data for the Powder River are summarized in Table 3-35. An analysis of DO concentrations found that there were few DO samples below the minimum DO criterion of 5 mg/L, and no samples since 1990 were below the criterion (Figure 3-31). In general, DO concentrations appear to be adequately supporting aquatic life uses in the Powder River.

A final water quality impairment determination will not be made for nutrients because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

Table 3-33. Summary of TP data, Powder River (mg/L).

Station	Count	Median	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder								
6325650	15	0.33	0.06	0.01	2.90	226%	9/1/78	6/25/01
6326000	7	1.22	0.12	0.03	7.10	214%	9/1/78	6/25/01
6326500	213	1.00	0.18	0.01	26.00	247%	10/23/74	8/21/02
6326520	7	0.26	0.17	0.02	1.10	146%	9/1/78	6/28/01
Upper Powder								
530	1	0.04	0.04	0.04	0.04	NA	6/25/01	6/25/01
6324500	187	0.91	0.19	0.00	22.00	257%	7/22/69	7/10/02
6324710	18	0.77	0.11	0.01	5.70	202%	9/1/78	6/25/01
Wyoming								
6312500	390	0.12	0.04	0.00	2.80	220%	10/26/73	7/23/91
6313500	224	0.34	0.06	0.01	5.10	202%	8/12/76	3/24/93
6313665	28	0.08	0.02	0.03	0.41	144%	8/31/78	11/2/89
6317000	173	0.48	0.09	0.00	10.40	237%	10/25/73	6/28/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-34. Summary of nitrite/nitrate data, Powder River (mg/L).

Station	Count	Median	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder								
6325650	4	0.05	0.22	0.01	0.85	188%	5/20/77	6/25/01
6326000	2	0.04	0.02	0.01	0.02	47%	9/1/78	6/25/01
6326500	100	0.30	0.37	0.00	1.50	74%	10/23/74	6/25/01
6326520	3	0.05	0.04	0.01	0.10	130%	9/1/78	6/28/01
Upper Powder								
373	1	0.03	0.03	0.03	0.03	NA	7/21/77	7/21/77
530	2	0.12	0.10	0.01	0.19	127%	7/22/77	6/25/01
6324500	103	0.30	0.35	0.00	2.20	91%	4/5/74	6/28/01
6324710	13	0.31	0.28	0.01	0.79	98%	3/5/75	6/25/01
Wyoming								
6312500	48	0.3	0.34	0.1	1	72%	10/20/78	6/26/89
6313500	72	0.4	0.49	0	4	140%	8/12/76	11/6/80
6313665	4	0.1	0.10	0.1	0	0%	8/31/78	10/17/78
6317000	9	0.05	0.23	0.01	0.90	167%	8/10/76	6/28/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-35. Summary of DO data, Powder River (mg/L).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder							
6325650	11	9.4	4.6	13.0	26%	7/27/88	11/7/89
6326000	3	8.5	8.3	8.6	2%	5/16/89	9/28/89
6326500	310	9.2	2.7	15.7	22%	10/23/74	9/27/01
6326520	3	7.9	7.6	8.2	4%	5/17/89	9/28/89
Upper Powder							
6324500	182	9.2	3.0	14.8	24%	7/22/69	7/10/02
6324710	14	9.3	4.4	12.6	24%	3/5/75	11/7/89
Wyoming							
6312500	254	9.9	6.2	16.7	19%	10/26/73	11/1/89
6313500	264	9.2	4.5	15.3	19%	8/12/76	8/16/00
6313605	6	8.8	4.8	12.4	32%	11/16/00	8/14/01
6313665	22	8.9	4	14.7	29%	7/26/88	11/2/89
6317000	88	8.8	2.9	13.4	24%	7/19/72	7/12/01

[a]CV – Coefficient of Variation (standard deviation/mean).

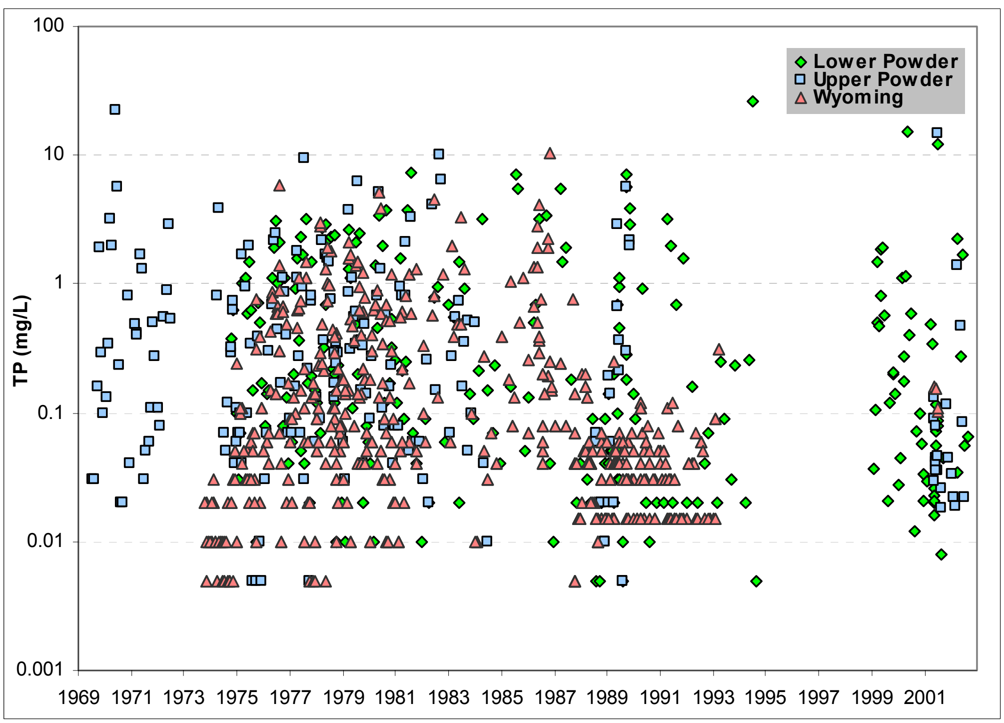

Figure 3-29. TP data for the Powder River (all stations).

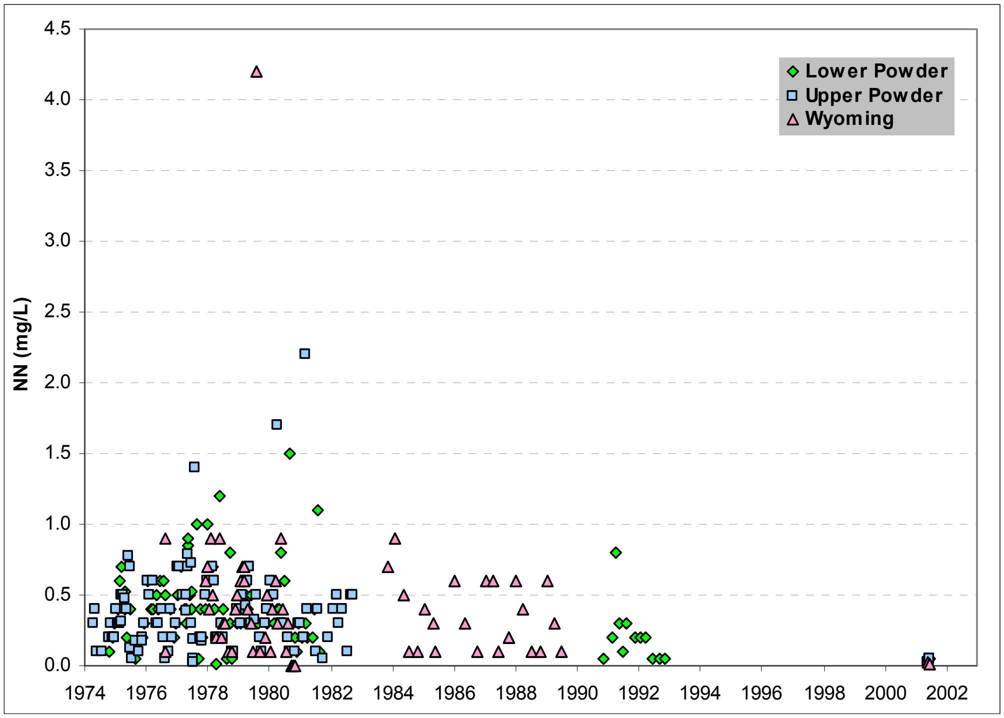

Figure 3-30. Nitrite/nitrate data for the Powder River (all stations).

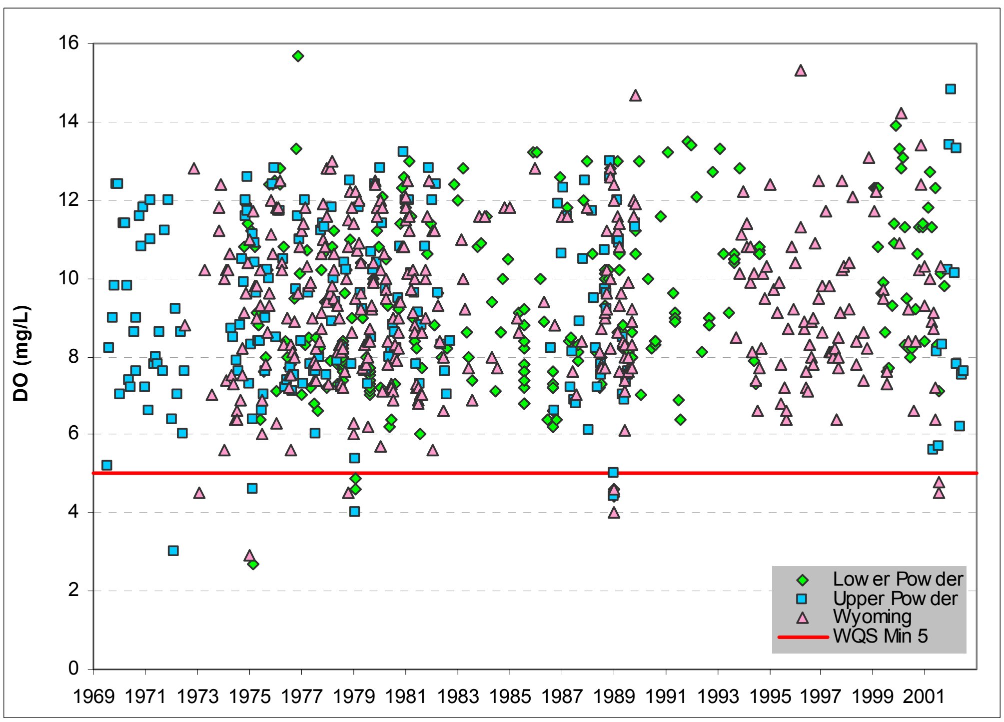

Figure 3-31. DO data for the Powder River (all stations).

3.3.1.3.8 Pathogens

As described in Section 3.4.1, the lower Powder River was listed as impaired for pathogens on the 1996 303(d) list. Recreational and drinking water uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to pathogens.

Montana fecal coliform standards apply to streams when the water temperature is greater than 60 degrees Fahrenheit. Figure 3-32 shows the distribution of temperature data in the Powder River. Temperatures were generally above 60 °F between May 15 and September 15. Because temperature data were not always sampled with pathogen data, only data from between these two dates were considered.

Tables 3-36 and 3-37 summarize the fecal coliform data in the Powder River, and Figure 3-33 shows long-term data at station 06326500. No long-term fecal coliform data were available for the upper Powder River. Most geometric means exceeded the 200 coliforms per 100 mL standard and some individual samples were several orders of magnitude above the 400 coliforms per 100 mL acute standard. Fecal coliform data are compared to Montana standards in Table 3-38. Standards apply to five or more samples obtained in a 30-day period. Three such cases existed in the lower Powder River and two cases in the upper Powder River. Both the geometric mean and acute fecal coliform standards were exceeded in the lower Powder River. The geometric mean standard was not exceeded in the upper Powder River; however, the acute standard was. Pathogen concentrations appeared to increase from upstream to downstream in 2001. Geometric means increased at each downstream station from June 26 to July 26, 2001.

Using the Montana contact recreation beneficial use support decision criteria, both the lower and upper Powder River are impaired because of fecal coliforms. Contact recreation is the only beneficial use impaired.

Table 3-36. Summary of all fecal coliform data, Powder River (count/100 mL).

Station	Count	Geometric Mean	Min	Max	Min Date	Max Date
Lower Powder						
6325650	4	724	228	1,860	6/27/01	7/17/01
6326000	5	600	148	5,172	6/26/01	7/17/01
6326500	137	139	1	130,000	10/20/76	7/17/01
6326520	5	1,201	236	21,430	6/26/01	7/17/01
Upper Powder						
530	4	323	157	517	6/26/01	7/17/01
6324500	5	391	172	1,012	6/26/01	7/17/01
6324710	6	365	137	1,223	6/26/01	7/17/01
Wyoming						
6312500	234	121	1	8,000	10/26/73	6/26/89
6313500	80	180	13	32,000	11/2/77	12/9/80
6317000	45	69	0	10,000	7/19/72	2/2/82

Table 3-37. Summary of fecal coliform data, Powder River (count/100 mL) (May 15–Sept 15).

Station	Count	Geometric Mean	Min	Max	Min Date	Max Date
Lower Powder						
6325650	4	724	228	1,860	6/27/01	7/17/01
6326000	5	600	148	5,172	6/26/01	7/17/01
6326500	57	629	2	130,000	5/25/77	7/17/01
6326520	5	1,201	236	21,430	6/26/01	7/17/01
Upper Powder						
530	4	323	157	517	6/26/01	7/17/01
6324500	5	391	172	1,012	6/26/01	7/17/01
6324710	6	365	137	1,223	6/26/01	7/17/01
Wyoming						
6312500	74	426	50	8,000	6/20/74	6/26/89
6313500	28	633	39	32,000	5/24/78	8/20/80
6317000	12	580	80	6,500	7/19/72	7/8/81

Table 3-38. Summary of fecal coliform exceedances at stations on the Powder River (May 15–September 15).

Station	Time Period	Total Number of Samples	Geometric Mean	Number of Samples ≥ 400	Percent of Samples ≥ 400
Lower Powder River					
06326520	6/26/01–7/26/01	5	1,201	3	60%
06326500	6/26/01–7/26/01	5	804	3	60%
06326000	6/26/01–7/26/01	5	600	2	40%
Upper Powder River					
6324710	6/26/01–7/26/01	6	365	2	33%
6324500	6/26/01–7/26/01	5	391	2	40%
Long Term Data					
06326500	5/25/77–7/26/01	57	629	29	51%

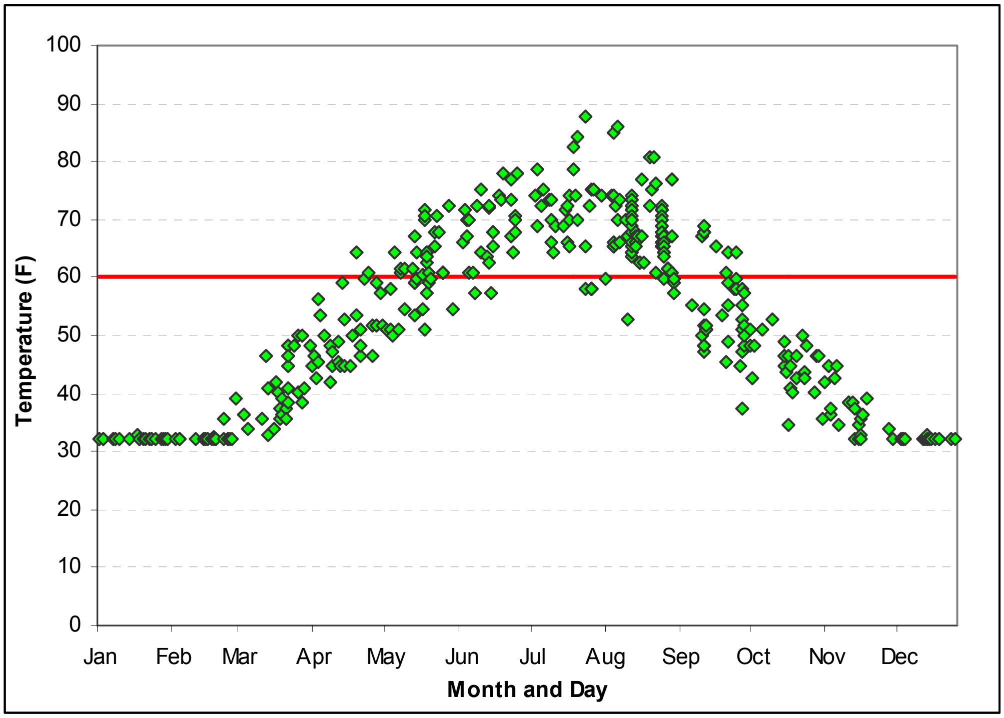

Figure 3-32. Water temperature distribution by day and month for the lower Powder River (1965-2000).

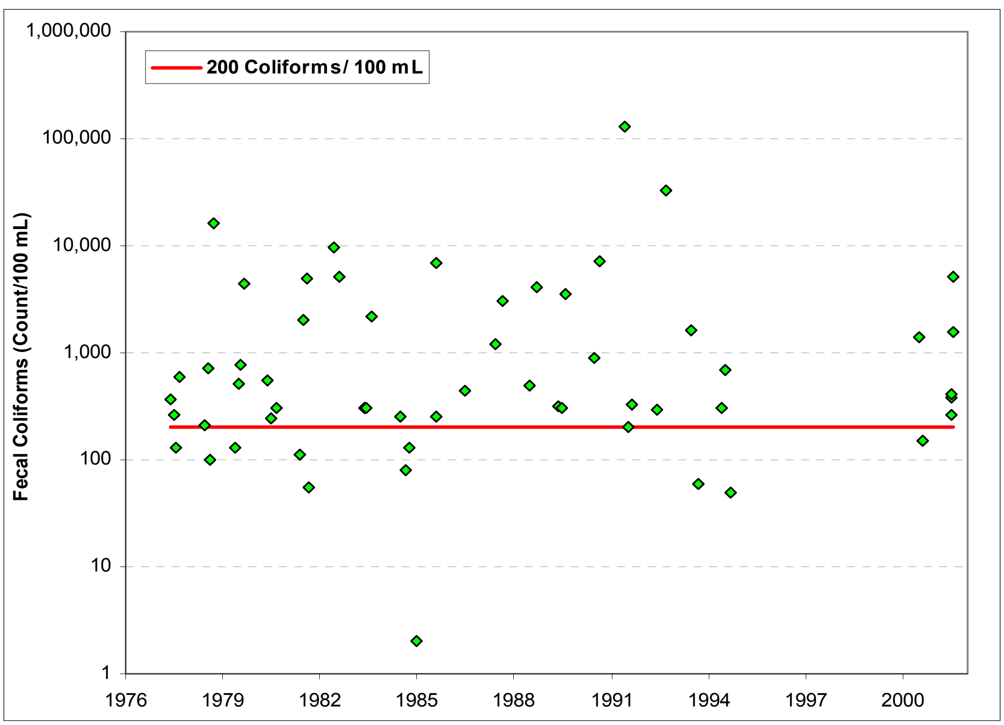

Figure 3-33. Fecal coliform data at station 06326500.

3.4.1.3.9 Total Suspended Solids

As described in Section 3.4.1, the lower Powder River was listed as impaired for total suspended solids (TSS) on the 1996 303(d) list. Aquatic life and fishery uses in the lower and upper segments of the Powder River were not evaluated for the 2002 303(d) list, and TSS was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Powder River to verify the impairment status relative to TSS.

There are no numeric water quality standards for TSS in Montana, and no reference conditions are available for the Powder River at this time. Both Utah and South Dakota have a TSS criterion of 90 mg/L for the protection of warmwater fishery streams, and South Dakota also has a criterion of 150 mg/L for the protection of marginal warmwater fishery streams. The 90 mg/L and 150 mg/L criteria were compared to the TSS data from the Powder River to provide some insight on use impairment status. However, a better target for prairie streams is needed to make more conclusive decisions. Others have indicated that high turbidity and sandy substrates are essential components for the organisms adapted to survive in the Powder River (Clancey, 2002).

A general summary of TSS data is shown in Table 3-39 and data are compared to Utah and South Dakota targets in Table 3-40. All TSS data in the Powder River watershed are shown in Figure 3-34. Figure 3-35 shows the average monthly TSS concentrations at three stations on the Powder River. The highest concentrations are found during the growing season between April and July, which corresponds to the high flow season in the Powder River. This is further verified by the relationships found between TSS and flow at USGS stations 06326500 and 06324500 in the lower and upper Powder River (Figures 3-36 and 3-37). Over 50 percent of the current samples (1996–2002) exceeded the 150 mg/L target in the lower Powder River. Twenty-five percent of the samples exceeded the 150 mg/L target in the upper Powder River. Periphyton sampling in the lower Powder River found that sediment was impairing aquatic life uses and the macroinvertebrate surveys also found severe sediment deposition at stations in the upper and lower Powder River (Bahls, 2000; Bollman, 2001).

The NRCS Phase II Stream Channel Assessment found that most of the Powder River channel (86 percent) had conditions that were at risk because of a lack of sustainability or functionality (NRCS, 2002). Specific conditions that caused segments of the Powder River to be classified as at risk included bank erosion, loss of vegetation, lack of sufficient root depth, and the presence of invasive species. Only 14 percent of the surveyed reaches were classified as sustainable. Sustainable conditions were defined as "the stream and associated riparian area had certain expected attributes, (e.g., flood plain, adequate riparian vegetation, sufficient soil, and channel characteristics) in place, and that processes such as energy dissipation, sediment trapping, and biotic function were working together to make the system stable" (NRCS, 2002). These findings indicate that there are potential anthropogenic sources of sediment in the Powder River watershed. However, it is not clear if these sources are impairing beneficial uses in the river.

A final water quality impairment determination will not be made for suspended solids because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

Table 3-39. Summary of TSS data, Powder River (mg/L).

Station	Count	Median	Average	Min	Max	CV[a]	Min Date	Max Date
Lower Powder								
6325650	6	44	4,496	10	26,800	243%	5/20/77	10/27/01
6326000	4	54	61	19	116	76%	5/25/01	10/28/01
6326500	273	863	3,998	1	41,400	176%	6/17/65	2/21/02
6326520	3	94	104	10	207	95%	5/25/01	10/28/01
Upper Powder								
373	1	40	40	40	40	NA	7/21/77	7/21/77
530	4	29	1,846	15	7,310	197%	7/22/77	8/18/01
6324500	180	1,470	4,408	1	52,200	198%	4/5/74	2/21/02
6324710	143	2,710	6,128	11	34,200	136%	3/5/75	1/16/02
Wyoming								
6313500	212	1,475	9,419	138	113,000	206%	1/4/67	10/15/87
6317000	116	5,965	18,153	111	122,000	141%	3/29/68	7/17/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-40. Summary of TSS exceedances.

Segment	Target	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Lower Powder	90 mg/L	286	244	85%	41	25	61%
Lower Powder	150 mg/L	286	227	79%	41	21	51%
Upper Powder	90 mg/L	328	287	88%	28	9	32%
Upper Powder	150 mg/L	328	271	83%	28	7	25%
Wyoming	90 mg/L	328	328	100%	7	7	100%
Wyoming	150 mg/L	328	323	98%	7	4	57%

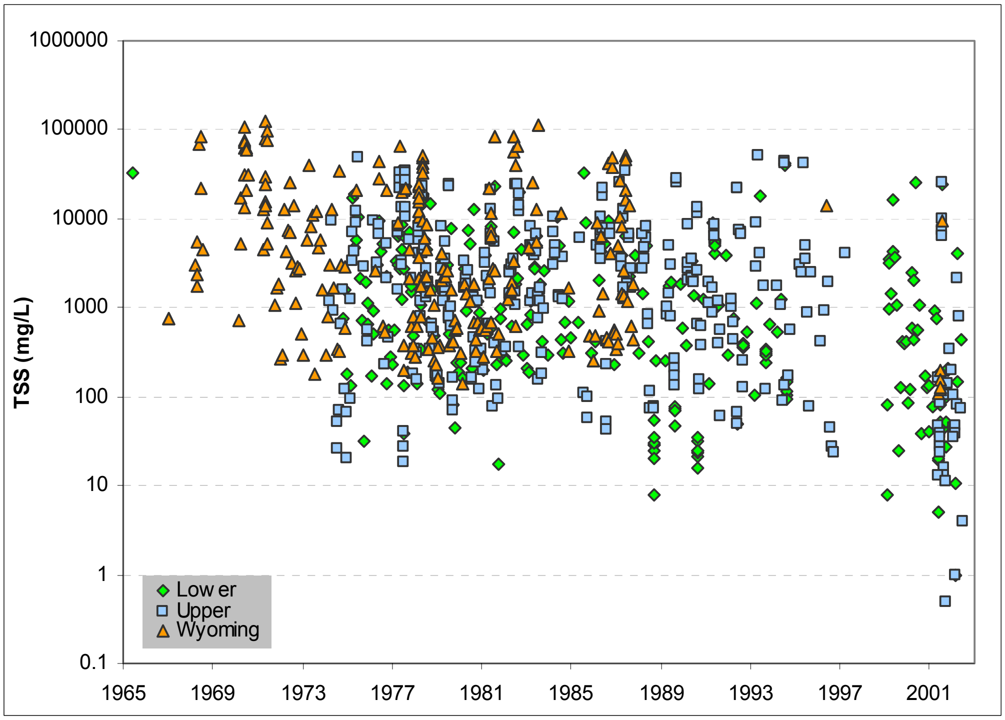

Figure 3-34. TSS data for the Powder River (all stations).

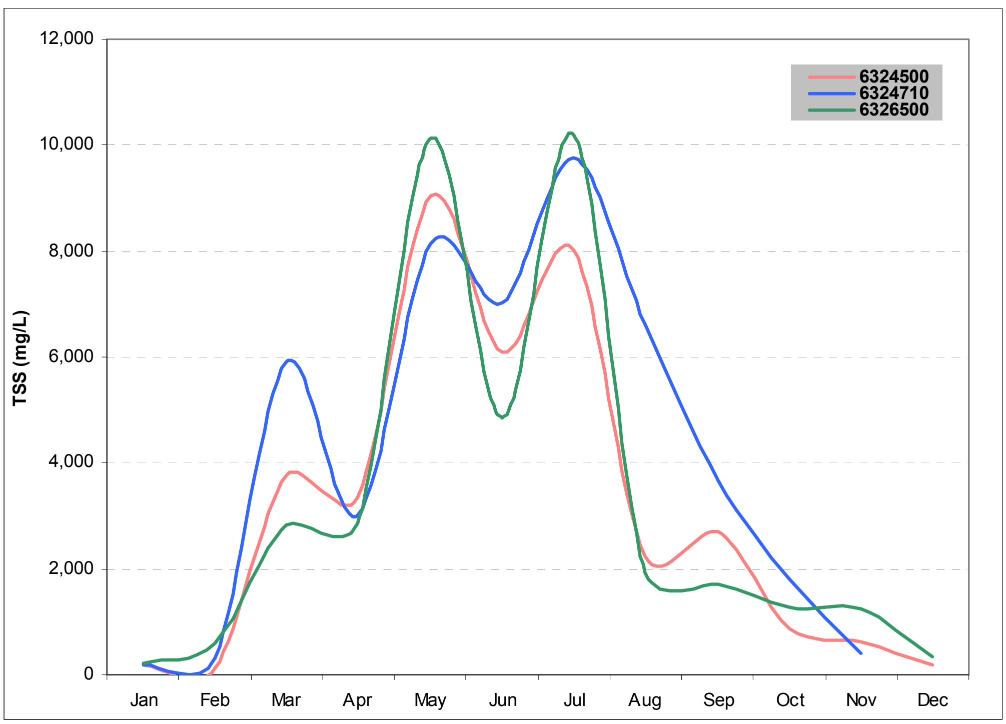

Figure 3-35. Average monthly TSS concentrations at three stations in the Powder River (1975-2002).

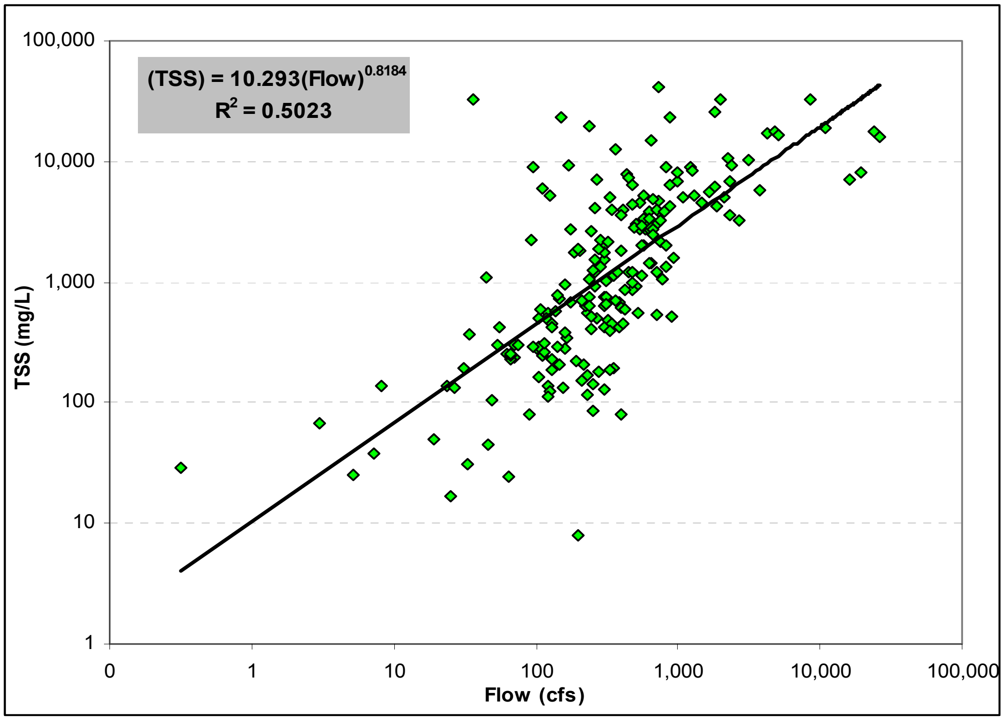

Figure 3-36. Relationship between TSS and flow at station 06326500.

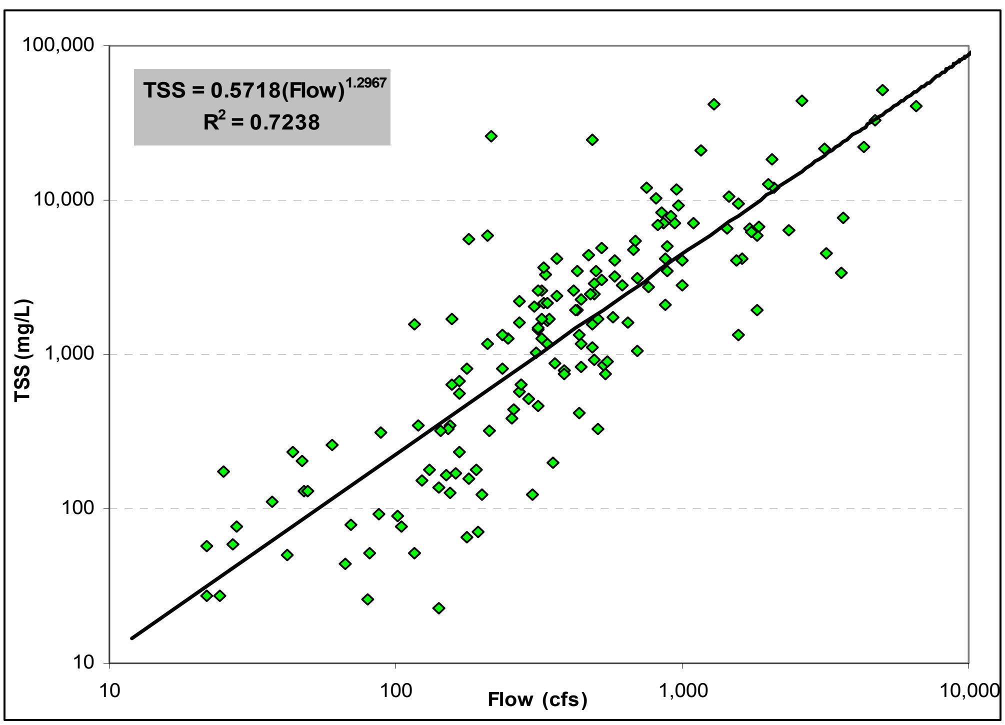

Figure 3-37. Relationship between TSS and flow at station 06324500.

3.4.1.3.10 Water Quality Impairment Status: Powder River

The Montana 1996 303(d) list reported that the lower segment of the Powder River was impaired because of salinity/TDS/chlorides, flow alterations, metals, nutrients, other inorganics, pathogens, and suspended solids. The upper Powder River was not listed on the 1996 303(d) list.

In 2002, the Montana 303(d) list reported that lower and upper segments of the Powder River were not assessed because of insufficient credible data. The 1996 causes of impairment were analyzed in the previous sections to determine which causes will require TMDLs. Water quality impairment determinations could not be made for several causes of impairment because appropriate site-specific numeric criteria have not been identified, or because there was a lack of recent data. A summary for each evaluated cause of impairment for each segment of the Powder River is shown in Table 3-41.

Table 3-41. Water quality impairment status summary for the Powder River.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Lower Powder River (from the mouth to the confluence with the Little Powder River)	Chlorides	✔		Undetermined
	Flow alteration	✔		No
	Metals	✔		Yes
	Nutrients	✔		Undetermined
	Other inorganics	✔		Undetermined
	Pathogens	✔		Yes
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended solids	✔		Undetermined
	Total dissolved solids	✔		Undetermined
Upper Powder River (from the confluence with the Little Powder River to the state line)	Chlorides			Undetermined
	Flow alteration			No
	Metals			Yes
	Nutrients			Undetermined
	Other inorganics			Undetermined
	Pathogens			Yes
	Salinity			Undetermined
	SAR			Undetermined
	Suspended solids			Undetermined
	Total dissolved solids			Undetermined

[a]Not all causes of impairment were evaluated for the 2002 303(d) list.
Source: MDEQ, 1996, 2002.

3.4.2 Little Powder River

The Montana 1996 303(d) list reported that the Little Powder River was impaired because of salinity/TDS/chlorides, other inorganics, suspended solids, siltation, and flow alterations. Agricultural, aquatic life, recreation, drinking water, swimmable, and fishery beneficial uses were impaired by these causes in 1996. In 2002, beneficial uses and causes of impairment for the Little Powder River were not assessed for the 303(d) report because of insufficient credible data. The discussion below provides a review of available data to evaluate the water quality impairment status.

3.4.2.1 Macroinvertebrates

The macroinvertebrate community in the Little Powder River was sampled in September 1999 to determine the aquatic life use conditions. The results of this study indicated that the site was only partially supporting its aquatic life use due to low scores for richness, diversity, and scraper and shredder metrics (Pfeiffer et al., 2000). The metals tolerance index for this site indicated that metals were not a cause of impairment, and no other potential causes or sources of impairment were identified.

3.4.2.2 Fish

No recent fish data were available at the time of this report.

3.4.2.3 Water Chemistry Assessment

Water chemistry data for the Little Powder River are available from 17 monitoring stations in Montana and Wyoming (Figure 3-38). These data have been collected by USGS and MDEQ and are summarized in the following sections.

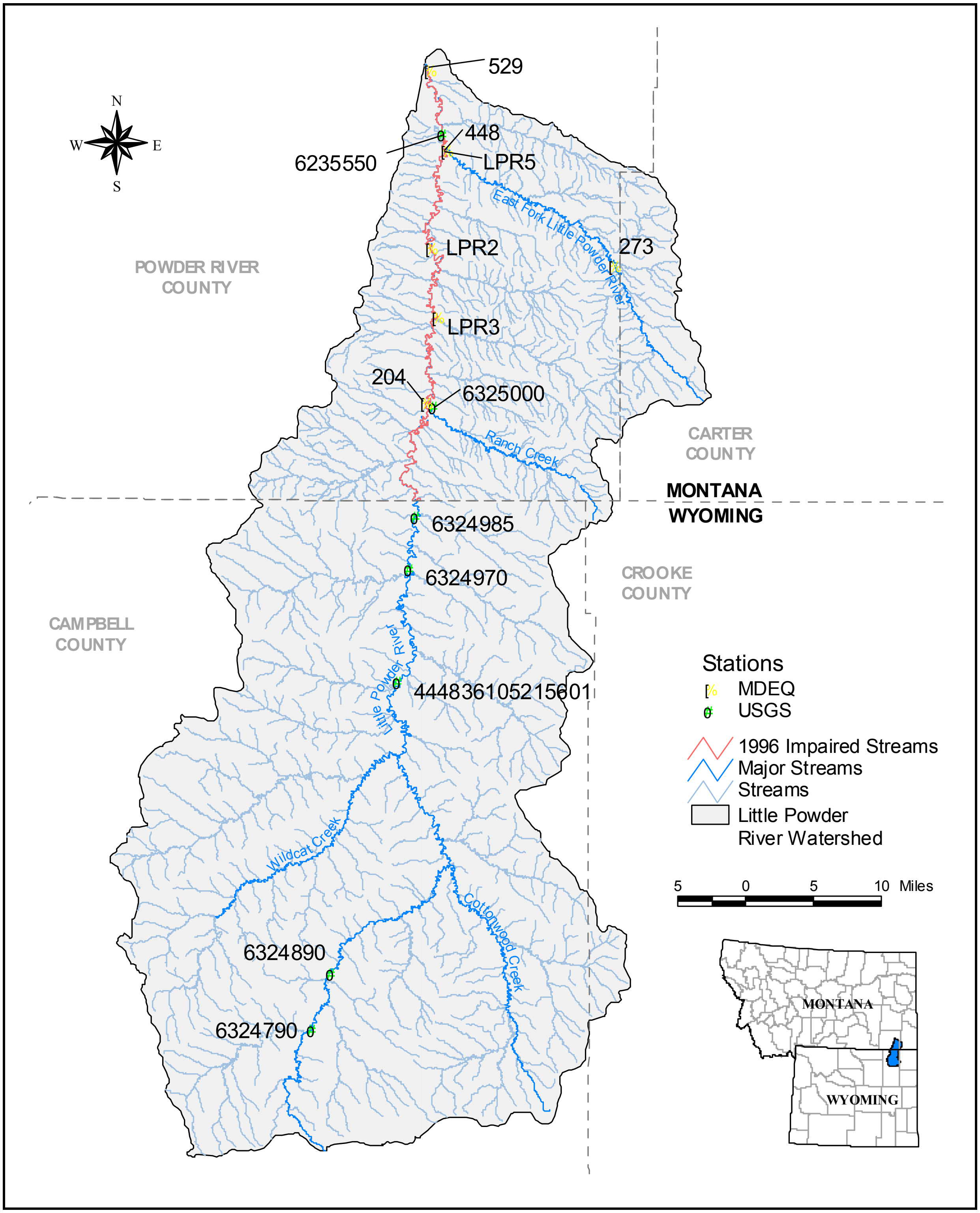

Figure 3-38. Location of the Little Powder River and the 1996 impaired streams.

3.4.2.3.1 Salinity

As described in Section 3.4.2, the Little Powder River was listed as impaired for salinity on the 1996 303(d) list. Agricultural uses in the Little Powder River were not evaluated for the 2002 303(d) list, and salinity was not identified as a cause of impairment for other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to salinity.

EC data are summarized in Tables 3-42 and 3-43 and are compared to proposed standards in Table 3-44. Almost all average EC values in Montana were greater than the proposed 1,900 µS/cm criterion. The coefficients of variation were generally low, indicating that instantaneous EC values do not vary much from average long-term values. Figures 3-39 and 3-40 show the EC data for the Little Powder River in Montana and Wyoming. The plots show that there is little seasonal difference between EC values and there is no apparent trend in EC over time. There is a weak relationship between EC and flow at USGS station 06324970. EC values are lower when flows are higher (Figure 3-41)

A final water quality impairment determination will not be made for salinity (EC) until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-42. Summary of EC data, Little Powder River (µS/cm) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
448	6	2,269	564	4,950	93%	2/21/74	11/21/75
6325500	5	3,648	2,670	4,630	20%	11/20/01	3/19/02
6325550	7	1,934	1,440	2,690	21%	12/5/88	11/9/89
Wyoming Stations							
6324790	1	1,780	1,780	1,780	0%	3/9/81	3/9/81
6324890	26	2,352	1,670	3,400	19%	11/4/76	3/4/83
6324970	99	3,196	394	5,500	38%	11/7/75	3/23/00
6324985	2	2,890	1,120	4,660	87%	1/23/70	2/25/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-43. Summary of EC data, Little Powder River (µS/cm) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
204	4	3,458	3,288	3,547	3%	9/16/76	5/4/77
448	11	2,994	1,529	4,056	24%	8/8/74	5/20/77
529	2	2,501	2,245	2,756	14%	10/31/74	9/16/76
6325000	3	3,541	3,234	3,750	8%	8/30/78	10/27/01
6325500	5	2,404	1,800	3,710	32%	10/2/01	7/11/02
6325550	23	2,313	1,560	3,290	22%	8/30/78	10/27/01
LPR2	2	3,379	3,372	3,385	0%	8/18/01	10/27/01
LPR3	1	3,475	3,475	3,475	0%	10/27/01	10/27/01
LPR5	3	3,270	2,865	3,604	11%	8/18/01	10/27/01
Wyoming Stations							
444836105215601	2	4,305	3,790	4,820	17%	8/30/78	10/21/78
6324790	11	1,676	840	3,300	50%	4/7/80	9/27/80
6324890	40	3,000	1,260	5,920	30%	6/3/75	8/12/83
6324970	198	2,674	373	5,500	40%	6/4/75	9/12/00
6324985	6	2,498	1,300	3,980	44%	5/12/69	5/26/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-44. Summary of EC exceedances (Montana stations).

Season	Salinity Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
APRIL–OCTOBER	1,900 µS/cm	54	50	93%	18	17	94%
NOVEMBER–MARCH	2,000 µS/cm	18	9	50%	5	5	100%

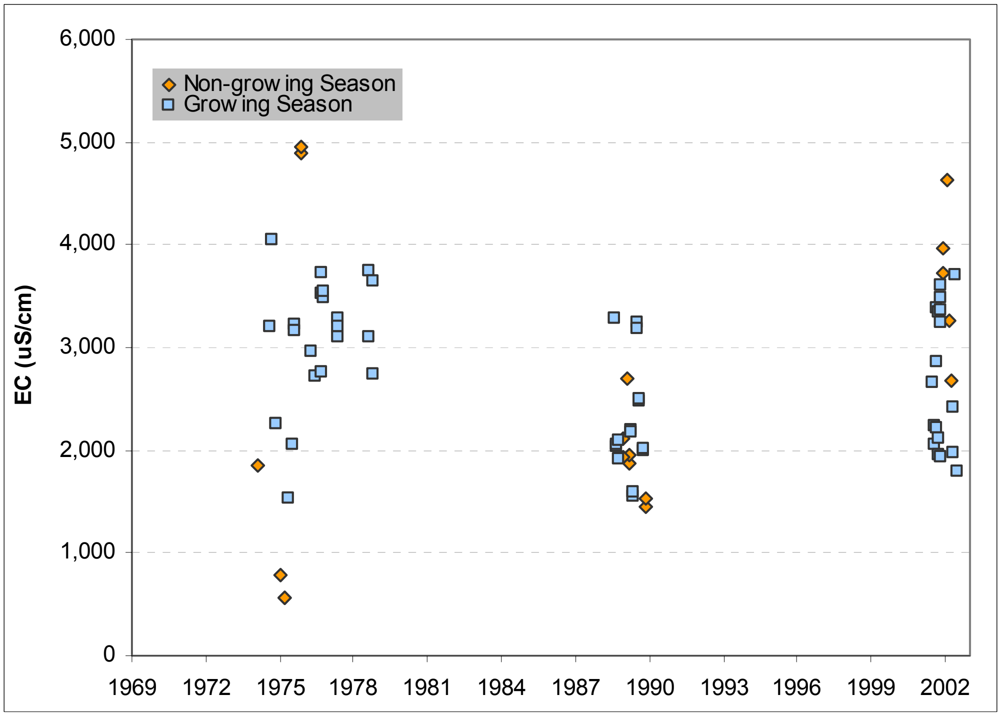

Figure 3-39. EC data for the Little Powder River in Montana (all stations).

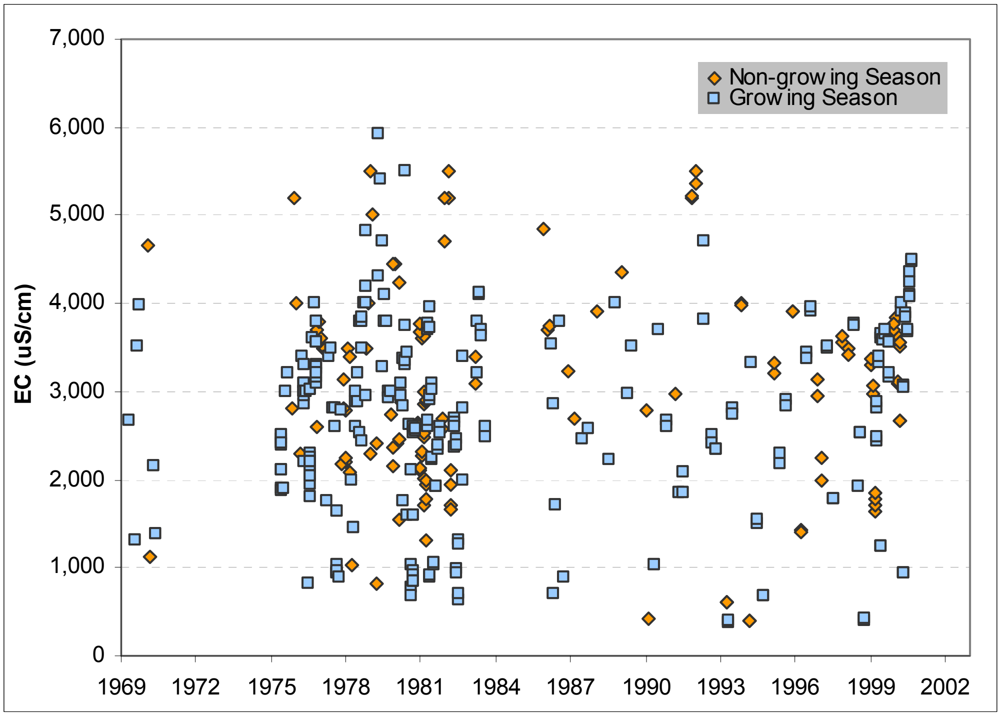

Figure 3-40. EC data for the Little Powder River in Wyoming (all stations).

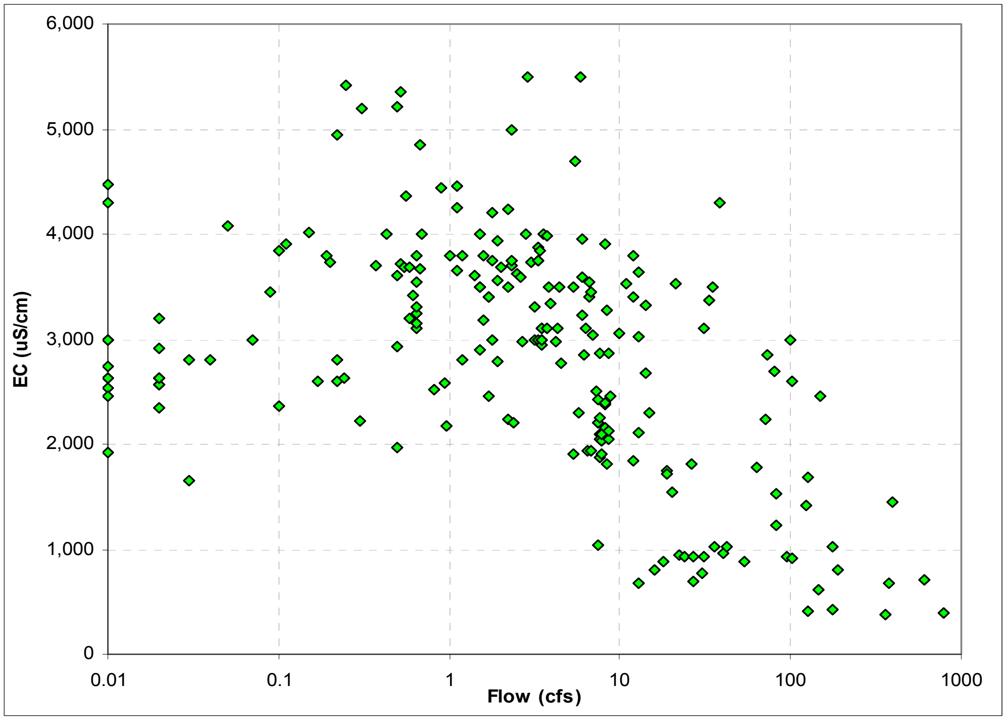

Figure 3-41. Relationship between EC and flow at USGS station 6324970.

3.4.2.3.2 Total Dissolved Solids

As described in Section 3.4.2, the Little Powder River was listed as impaired for total dissolved solids (TDS) on the 1996 303(d) list. Agricultural uses in the Little Powder River were not evaluated for the 2002 303(d) list, and TDS was not identified as a cause of impairment for any other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to TDS.

Section 3.4.2.3.1 described salinity concentrations (measured as EC) in the Little Powder River. EC is an indirect measurement of TDS and salinity. The relationship between TDS and EC is different for each waterbody, and varies with the type of ions in solution, temperature, and barometric pressure. Figure 3-42 shows the relationship between EC and TDS in the Little Powder River in Montana. This graph shows EC and TDS data obtained on the same date and location, and confirms the strong relationship between EC and TDS. The relationship between the two parameters is EC = 1.21(TDS). Therefore, an EC of 1,900 µS/cm is equivalent to a TDS concentration of 1,570 mg/L and an EC of 2,000 µS/cm is equivalent to 1,653 mg/L. At station 06324970, the major ions measured by TDS were on average sulfate (57 percent), sodium (18 percent), calcium (7 percent), chloride (1 percent), and magnesium (4 percent).

TDS data for the growing season and non-growing seasons are summarized in Tables 3-45 and 3-46. Average values during the growing season regularly exceeded calculated TDS targets. Figures 3-43 and 3-44 show that there was no apparent trend in TDS values in the Montana or Wyoming segments of the Little Powder River. Concentrations consistently exceed the calculated TDS targets.

A final water quality impairment determination will not be made for TDS until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2).

Table 3-45. Summary of TDS, Little Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana							
448	3	2,098	389	4,487	102%	2/21/74	11/21/75
Wyoming							
6324890	34	2,057	1,310	2,770	17%	11/4/76	3/4/83
6324970	64	2,575	521	4,380	33%	11/7/75	3/23/00
6324985	4	2,419	791	4,050	77%	1/23/70	2/25/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-46. Summary of TDS, Little Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana							
204	3	2,733	2,624	2,863	4%	9/16/76	5/4/77
273	1	1,162	1,162	1,162	NA	9/16/76	9/16/76
448	10	2,277	1,325	3,275	28%	8/8/74	5/20/77
529	2	1,973	1,816	2,129	11%	10/31/74	9/16/76
6325000	5	3,051	2,860	3,290	5%	8/30/78	10/27/01
6325550	8	2,008	1,460	2,410	17%	8/30/78	10/27/01
LPR002	2	3,156	2,990	3,321	7%	8/18/01	10/27/01
LPR003	1	3,427	3,427	3,427	NA	10/27/01	10/27/01
LPR005	3	2,815	2,230	3,235	19%	8/18/01	10/27/01
Wyoming							
6324890	50	2,641	915	5,710	40%	5/5/76	8/12/83
6324970	133	2,054	380	3,880	41%	6/4/75	9/12/00
6324985	12	2,012	924	3,340	47%	5/12/69	5/26/70

[a]CV – Coefficient of Variation (standard deviation/mean).

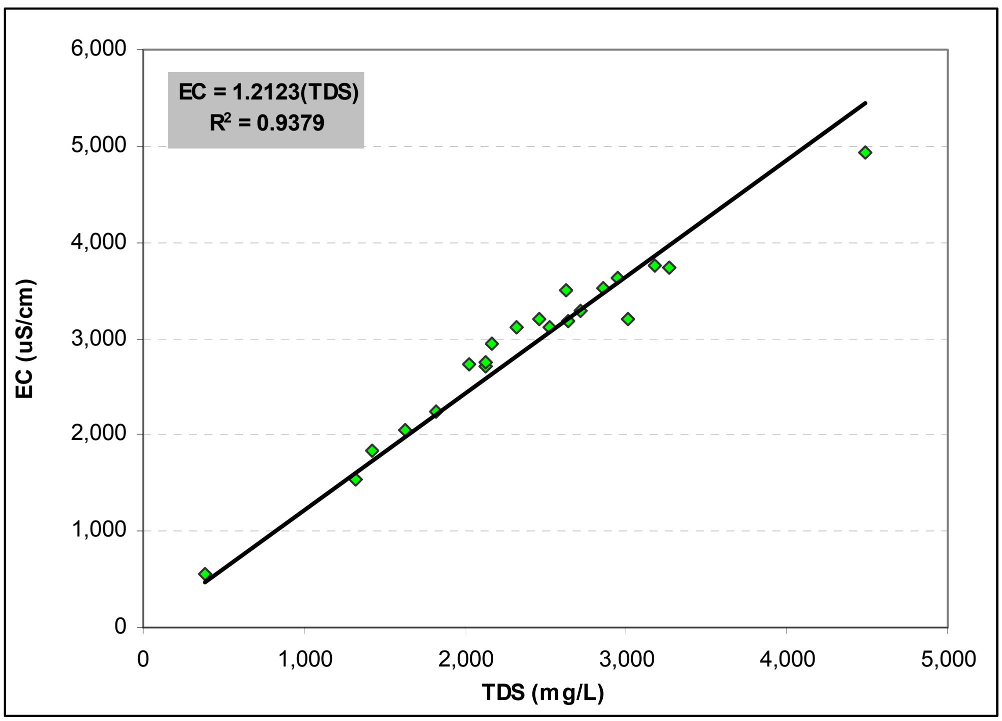

Figure 3-42. Relationship between TDS and EC in the Little Powder River.

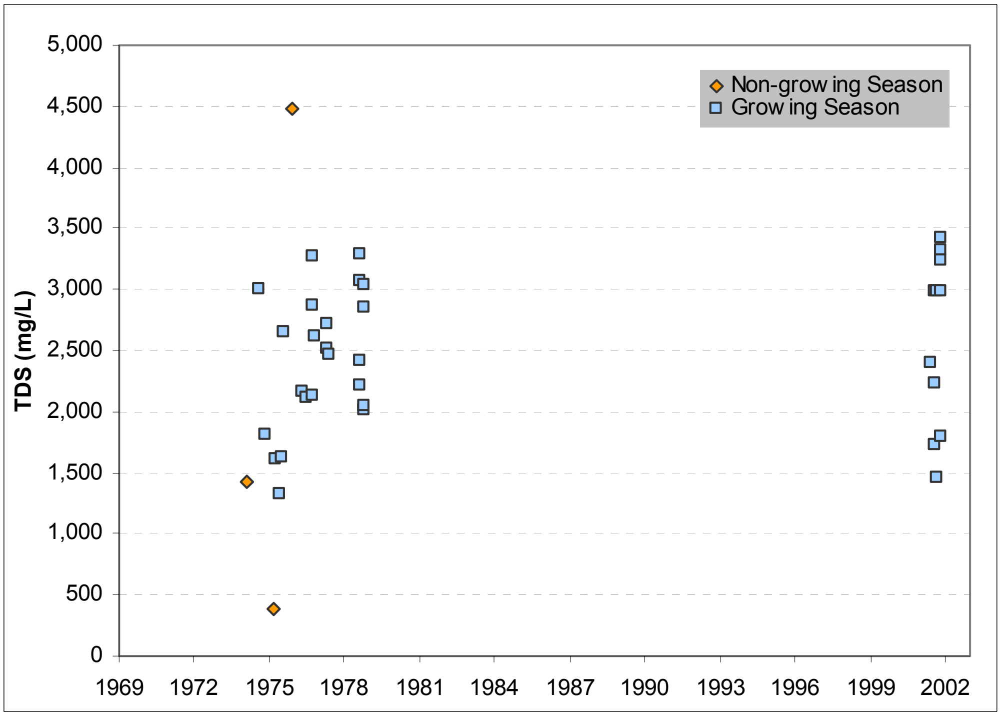

Figure 3-43. TDS data for the Little Powder River in Montana (all stations).

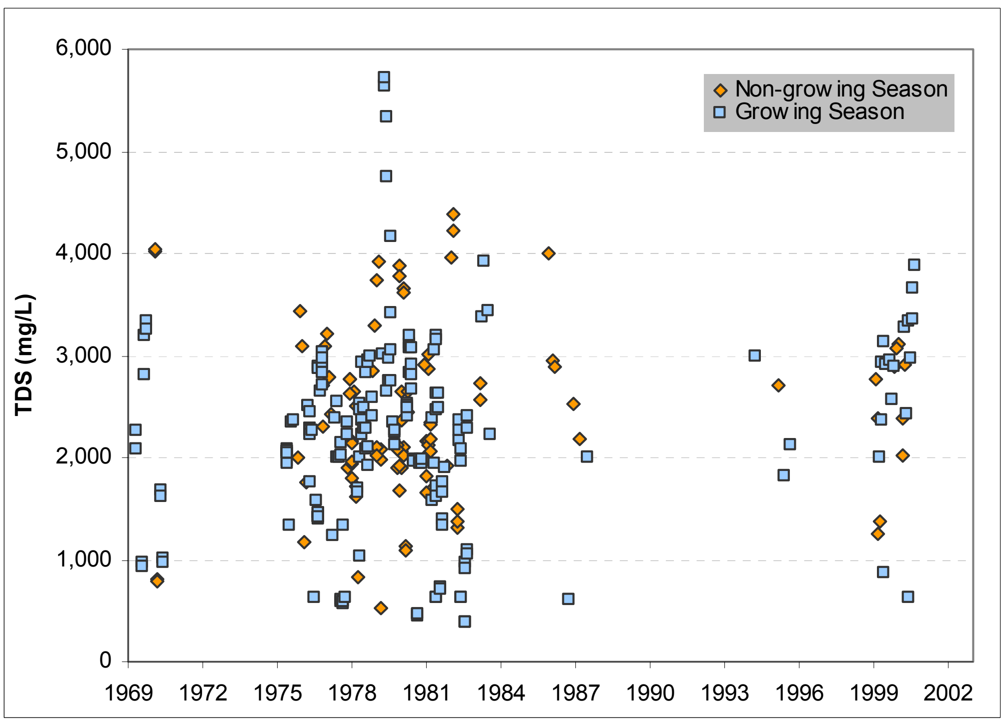

Figure 3-44. TDS data for the Little Powder River in Wyoming (all stations).

3.4.2.3.3 Chloride

As described in Section 3.4.2, the Little Powder River was listed as impaired for chlorides on the 1996 303(d) list. Agricultural, aquatic life, and fishery uses in the Little Powder River were not evaluated for the 2002 303(d) list, and chloride was not identified as a cause of impairment for other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to chlorides.

USEPA recommended chloride standards for streams and rivers based on the aquatic toxicity of plant, fish, and invertebrate species (USEPA, 1999). USEPA recommends an acute standard of 860 mg/L and a chronic standard of 230 mg/L. Montana does not have numeric standards for chlorides.

Chloride data for the Little Powder River are summarized in Tables 3-47 and 3-48. Average concentrations were lower than EPA proposed standards. Figures 3-45 and 3-46 show that there appears to be a significant increase in chloride concentrations over time, but few samples exceeded the EPA proposed standard of 230 mg/L.

Based on an analysis of available data, chlorides are not impairing agricultural or aquatic life uses in the Little Powder River. Chloride concentrations for the river were much lower than the USEPA recommended standards to protect aquatic life uses. Concentrations were also much lower than the calculated TDS targets to protect agricultural uses (see Section 3.4.1.3.2).

Table 3-47. Summary of chloride data, Little Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana							
448	4	28.2	16.2	41.8	43%	2/21/74	11/21/75
6325500	5	48.7	36.0	61.2	19%	11/20/01	3/19/02
6325550	3	6.5	5.5	8.2	23%	12/5/88	11/9/89
Wyoming							
6324890	18	8.7	5.1	12.0	24%	11/4/76	3/4/83
6324970	68	39.7	3.2	580.0	180%	11/7/75	3/23/00
6324985	2	10.6	4.1	17.0	86%	1/23/70	2/25/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-48. Summary of chloride data, Little Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana							
204	3	207.3	55.0	331.0	68%	9/16/76	5/4/77
448	11	40.6	0.8	123.0	91%	8/8/74	5/20/77
529	2	11.5	1.0	22.0	129%	10/31/74	9/16/76
6325000	3	37.7	26.0	60.0	51%	8/30/78	10/27/01
6325500	5	25.0	5.3	45.5	69%	10/2/01	7/11/02
6325550	14	28.3	4.7	200.0	177%	8/30/78	10/27/01
LPR2	2	98.0	80.0	116.0	26%	8/18/01	10/27/01
LPR3	1	73.0	73.0	73.0	NA	10/27/01	10/27/01
LPR5	3	56.0	38.0	77.0	35%	8/18/01	10/27/01
Wyoming							
6324890	28	14.2	5.6	26.0	39%	5/5/76	8/12/83
6324970	144	20.9	2.6	199.0	129%	6/4/75	9/12/00
6324985	6	9.3	4.2	16.0	51%	5/12/69	5/26/70

[a]CV – Coefficient of Variation (standard deviation/mean).

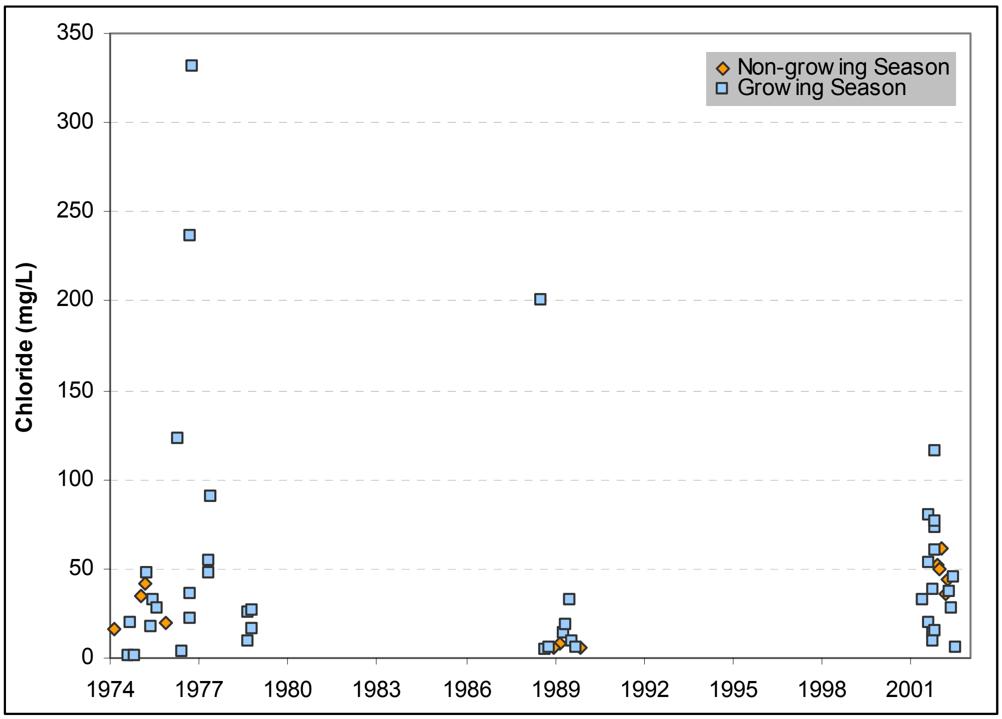

Figure 3-45. Chloride data for the Little Powder River in Montana (all stations).

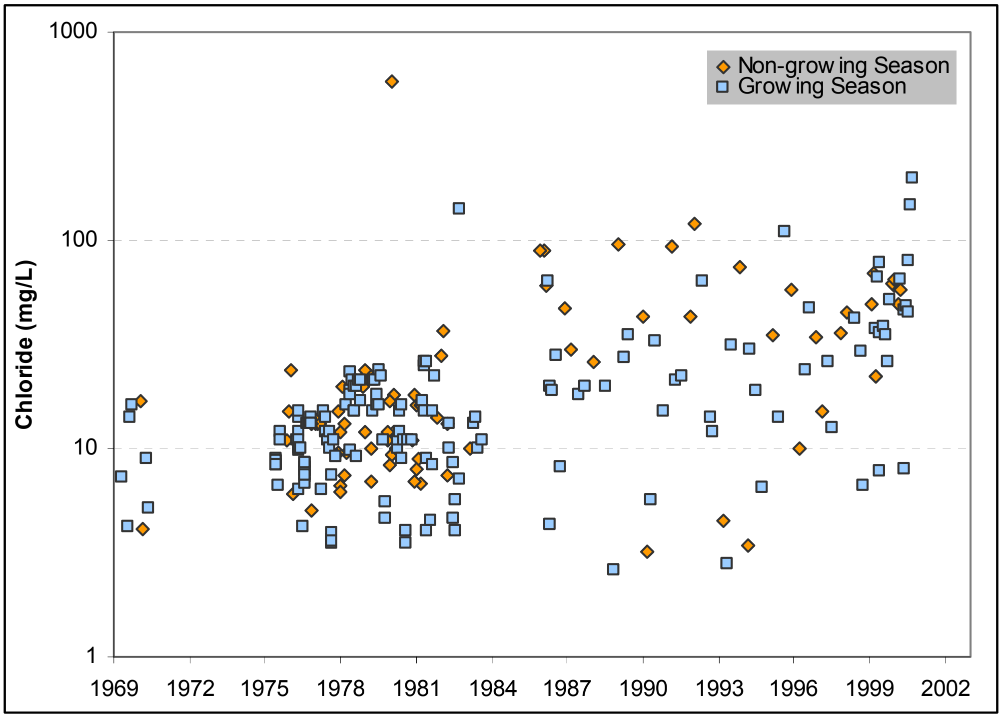

Figure 3-46. Chloride data for the Little Powder River in Wyoming (all stations).

3.4.2.3.4 SAR

The Little Powder River was not listed as impaired for SAR on the 1996 303(d) list. Agricultural uses in the Little Powder River were not evaluated for the 2002 303(d) list, and SAR was not identified as a cause of impairment for other uses. This section presents an updated evaluation of all segments of the Little Powder River to verify the impairment status relative to SAR.

SAR data for the Little Powder River are summarized in Tables 3-49 and 3-50, and SAR exceedances in Table 3-51. Almost all SAR samples exceeded the proposed SAR criteria. Figures 3-47 and 3-48 show that most samples in the Montana and Wyoming segments of the Little Powder River were higher than the maximum allowable SAR value of 5. There does not appear to be a trend in the SAR data for either segment, and there is no apparent difference between values during the growing season and non-growing season.

A final water quality impairment determination will not be made for SAR until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-49. Summary of SAR data in the Little Powder River (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
204	3	10.4	7.0	13.0	30%	9/16/76	5/4/77
448	11	7.6	5.2	10.9	24%	8/8/74	5/20/77
529	2	9.7	9.5	9.9	3%	10/31/74	9/16/76
LPR2	2	5.4	5.0	5.7	9%	8/18/01	10/27/01
LPR3	1	7.5	7.5	7.5	NA	10/27/01	10/27/01
LPR5	3	8.2	7.2	9.1	12%	8/18/01	10/27/01
6325000	2	8.0	7.6	8.3	6%	8/30/78	10/21/78
6325500	5	11.2	8.8	16.1	27%	10/2/01	7/11/02
6325550	10	9.8	6.2	14.2	30%	8/30/78	9/29/89
Wyoming Stations							
6324890	27	2.5	1.4	4.6	31%	5/5/76	8/12/83
6324970	111	5.9	2.2	9.6	32%	6/4/75	9/12/00
6324985	6	5.9	3.4	9.9	45%	5/12/69	5/26/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-50. Summary of SAR data in the Little Powder River (November 1–March 31)

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
448	3	6.4	3.0	11.3	68%	2/21/74	11/21/75
6325500	5	7.6	6.9	9.2	12%	11/20/01	3/19/02
6325550	4	11.0	9.8	12.2	12%	12/5/88	11/9/89
Wyoming Stations							
6324890	18	2.1	1.3	7.2	66%	11/4/76	3/4/83
6324970	68	6.5	1.5	12.6	33%	11/7/75	3/23/00
6324985	2	6.9	4.1	9.7	58%	1/23/70	2/25/70

[a]CV – Coefficient of Variation (standard deviation/mean).

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Table 3-51. Summary of SAR exceedances at stations on the impaired streams.

Segment	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Montana[a]	51	50	98%	16	16	100%

[a]Reported data are from sample dates with both an SAR and salinity measurement, and criteria are based on the formula SAR <= (EC * 0.0071) – 2.475.

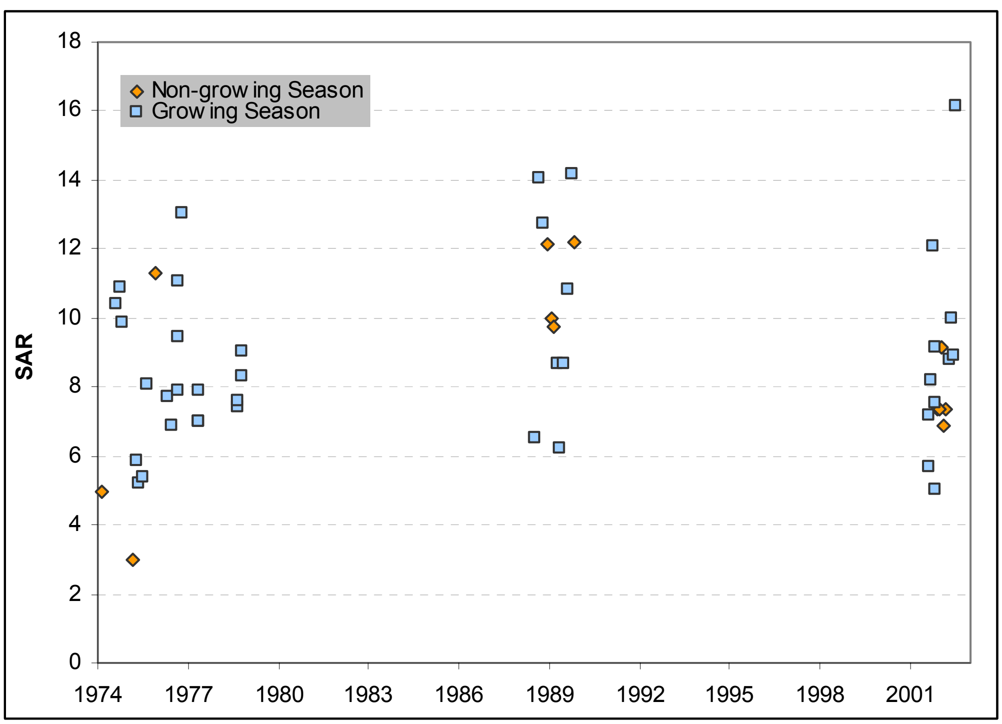

Figure 3-47. SAR data for the Little Powder River in Montana (all stations).

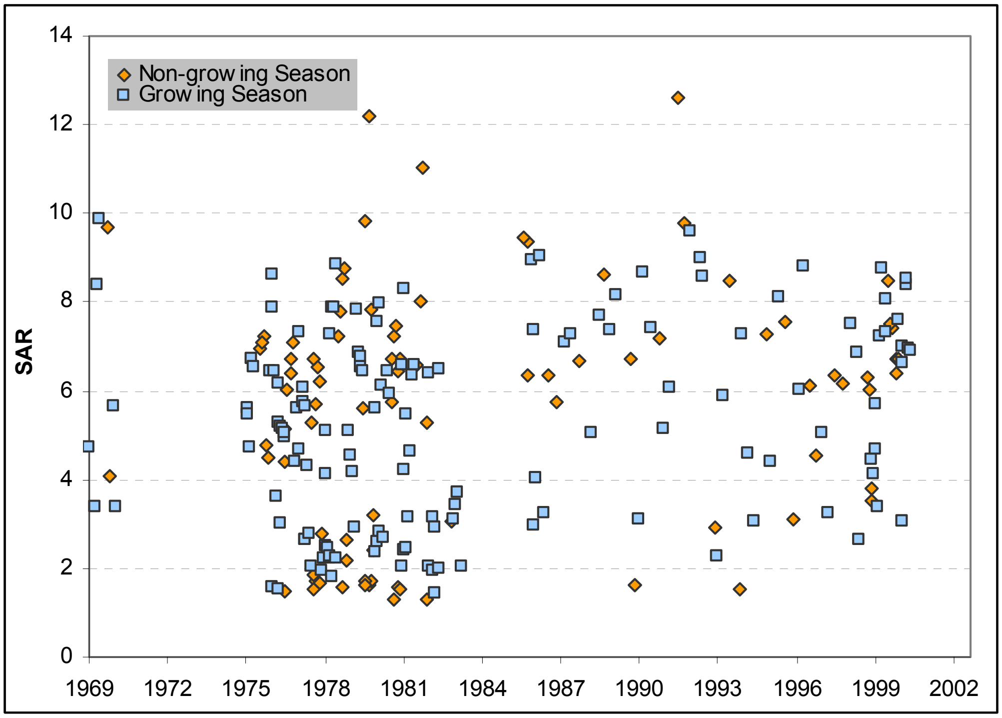

Figure 3-48. SAR data for the Little Powder River in Wyoming (all stations).

3.4.2.3.5 Sulfate

As described in Section 3.4.2, the Little Powder River was listed as impaired for other inorganics (sulfate) on the 1996 303(d) list. Agricultural uses in the Little Powder River were not evaluated for the 2002 303(d) list, and sulfate was not identified as a cause of impairment for other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to sulfates. Montana currently has no numeric standards for sulfate. EPA has a sulfate secondary drinking water standard of 250 mg/L. Several states (North Dakota, New Mexico, South Dakota, Utah) have chosen statewide or site-specific sulfate standards of 250, 500, or 750 mg/L.

As stated in Section 3.4.2.3.2, surrogate TDS targets for the Little Powder River are 1,570 mg/L (April 1–October 31) and 1,653 mg/L (November 1 –March 31). These targets were used to help determine sulfate impairments in the Little Powder River because TDS is partially composed of sulfates. By definition, the dissolved sulfate concentration in a stream must be equal to or less than the TDS concentration.

Tables 3-52 and 3-53 summarize the sulfate data for the Little Powder River. Sulfate concentrations were generally much higher than the secondary drinking water standard of 250 mg/L. Several samples exceeded the calculated TDS targets in both the Montana and Wyoming segments of the Little Powder River (Figures 3-49 and 3-50).

A final water quality impairment determination will not be made for sulfate until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2).

Table 3-52. Summary of sulfate data for the Little Powder River (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
448	4	916	106	2,620	127%	2/21/74	11/21/75
6325500	5	1,682	1,100	2,220	25%	11/20/01	3/19/02
6325550	4	613	420	800	26%	12/5/88	11/9/89
Wyoming Stations							
6324890	18	1,217	700	1,600	21%	11/4/76	3/4/83
6324970	68	1,431	110	2,700	41%	11/7/75	3/23/00
6324985	2	1,428	445	2,410	97%	1/23/70	2/25/70

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-53. Summary of sulfate data for the Little Powder River (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
204	3	1,223	915	1,440	22%	9/16/76	5/4/77
448	10	1,221	670	1,898	35%	8/8/74	5/20/77
529	2	930	820	1,040	17%	10/31/74	9/16/76
6325000	3	1,760	1,680	1,900	7%	8/30/78	10/27/01
6325500	5	925	506	1,690	49%	10/2/01	7/11/02
6325550	14	952	520	1,500	34%	8/30/78	10/27/01
LPR2	2	1,695	1,680	1,710	1%	8/18/01	10/27/01
LPR3	1	1,780	1,780	1,780	NA	10/27/01	10/27/01
LPR5	3	1,567	1,230	1,790	19%	8/18/01	10/27/01
Wyoming Stations							
6324890	28	1,624	560	3,900	45%	5/5/76	8/12/83
6324970	144	1,212	94	2,400	45%	6/4/75	9/12/00
6324985	6	1,203	540	2,160	54%	5/12/69	5/26/70

[a]CV – Coefficient of Variation (standard deviation/mean).

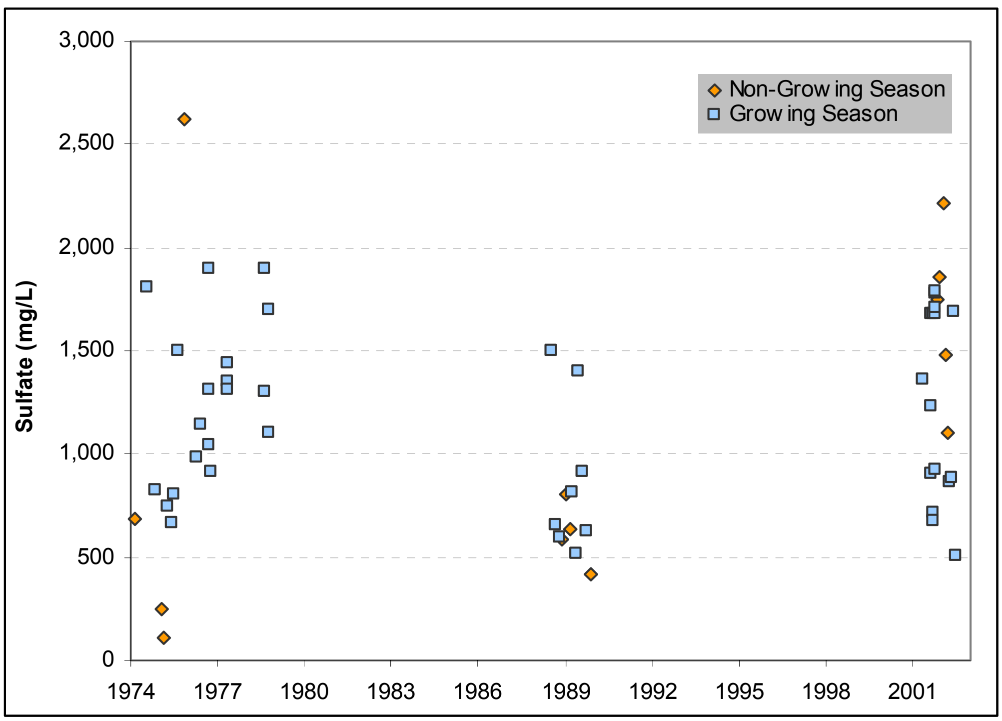

Figure 3-49. Sulfate data for the Little Powder River in Montana (all stations).

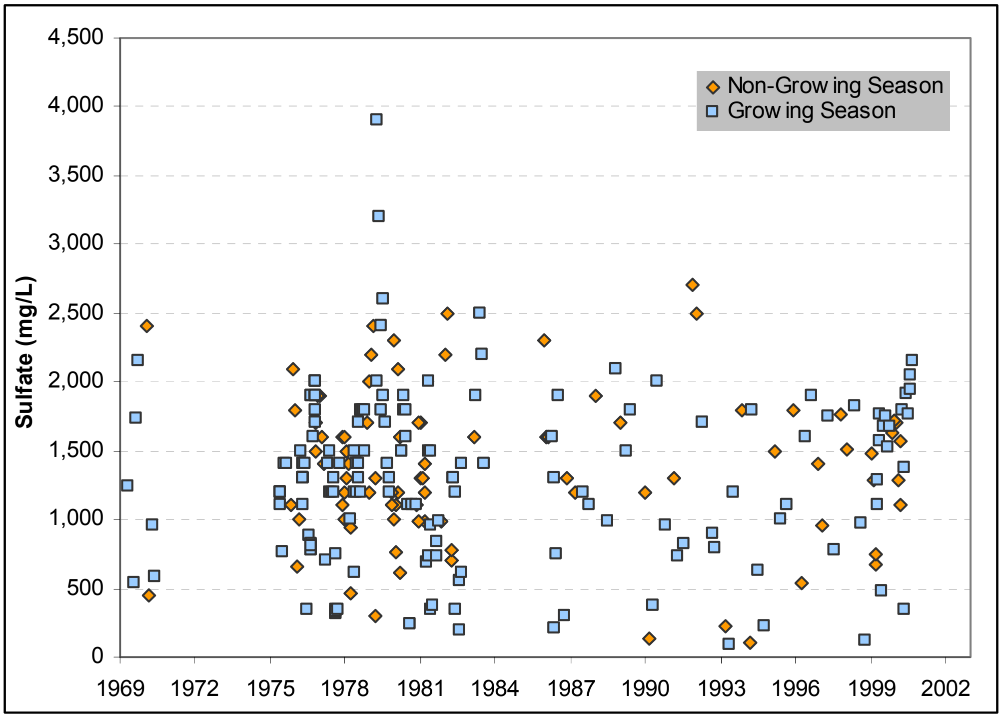

Figure 3-50. Sulfate data for the Little Powder River in Wyoming (all stations).

3.4.2.3.6 Total Suspended Solids

As described in Section 3.4.2, the Little Powder River was listed as impaired for total suspended solids (TSS) on the 1996 303(d) list. Aquatic life and fishery uses in the Little Powder River were not evaluated for the 2002 303(d) list, and TSS was not identified as a cause of impairment for other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to TSS.

There are no numeric water quality standards for TSS in Montana, and no reference conditions are available for the Little Powder River at this time. Both Utah and South Dakota have a TSS criterion of 90 mg/L for the protection of warmwater fishery streams, and South Dakota also has a criterion of 150 mg/L for the protection of marginal warmwater fishery streams. The TSS data from the Little Powder River were compared to Utah's and South Dakota's TSS criteria to provide some insight on use impairment status. However, a better target for prairie streams is needed to make more conclusive decisions.

A general summary of TSS data is shown in Table 3-54. All TSS data in the Montana and Wyoming segments of the Little Powder River are shown in Figure 3-51. There was a wide range of TSS concentrations recorded in the Little Powder River. The maximum recorded concentration was 19,400 mg/L and the minimum concentration was 1.0 mg/L. Figure 3-51 shows that there was no apparent trend in the TSS data over time, and concentrations in the Montana and Wyoming segments of the river were similar. Figure 3-52 shows that TSS and flow are weakly related: TSS concentrations increase with increasing flow.

The NRCS Phase II Stream Channel Assessment found that 100 percent of the Little Powder River channel had sustainable conditions. Sustainable conditions were defined as "the stream and associated riparian area had certain expected attributes (e.g., flood plain, adequate riparian vegetation, sufficient soil, and channel characteristics) in place, and that processes such as energy dissipation, sediment trapping, and biotic function were working together to make the system stable" (NRCS, 2002). There was little evidence of anthropogenic sources of sediment near the stream channel.

A final water quality impairment determination will not be made for suspended solids because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

Table 3-54. Summary of TSS data, Little Powder River (mg/L).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Montana Stations							
204	1	71	71	71	NA	5/4/77	5/4/77
448	7	347	10	950	115%	3/5/75	5/20/77
6325000	1	10	10	10	NA	10/27/01	10/27/01
6325500	9	117	50	202	49%	10/2/01	7/11/02
6325550	7	84	18	183	79%	7/26/88	10/27/01
LPR2	2	75	31	119	83%	8/18/01	10/27/01
LPR3	1	18	18	18	NA	10/27/01	10/27/01
LPR5	3	44	25	74	59%	8/18/01	10/27/01
Wyoming Stations							
6324890	58	71	1	1,120	214%	6/3/75	8/12/83
6324970	155	1,149	8	19,400	259%	1/8/75	9/12/00

[a]CV – Coefficient of Variation (standard deviation/mean).

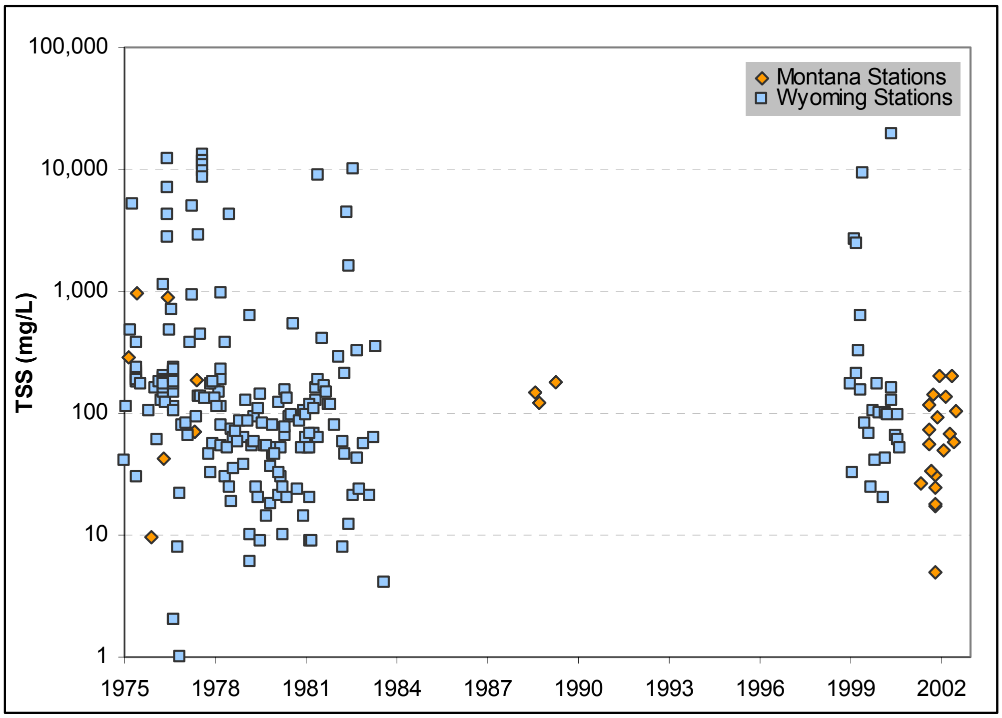

Figure 3-51. TSS data for the Little Powder River (all stations).

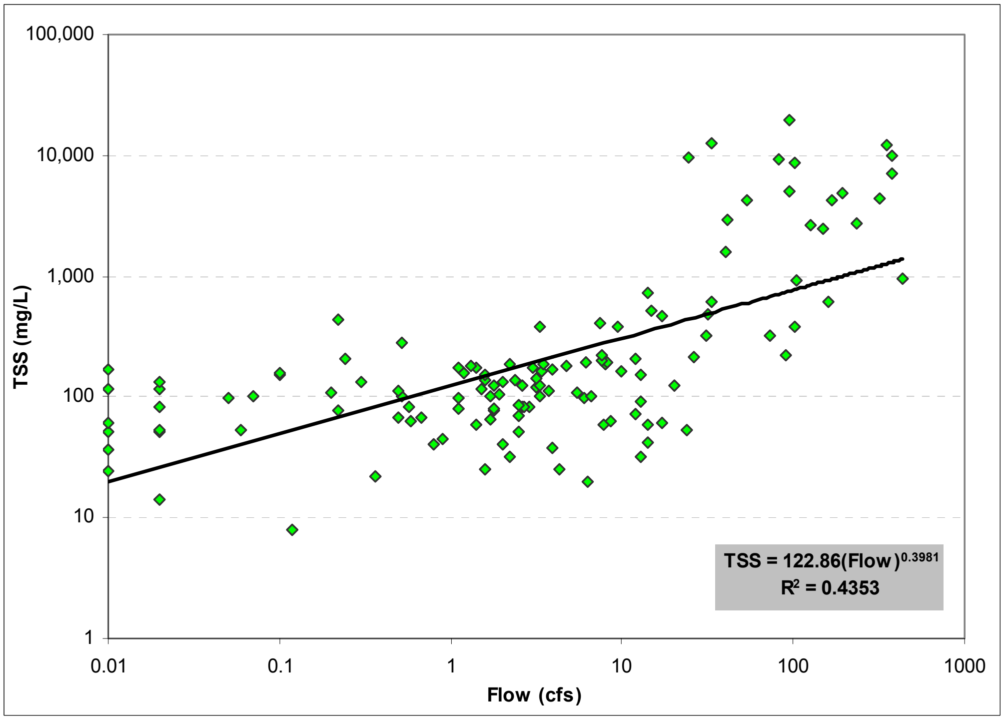

Figure 3-52. Relationship between flow and TSS at USGS station 6324970.

3.4.2.3.7 Siltation

As described in Section 3.4.2, the Little Powder River was listed as impaired for siltation on the 1996 303(d) list. Aquatic life and fishery uses in the Little Powder River were not evaluated for the 2002 303(d) list, and siltation was not identified as a cause of impairment for other uses. This section presents an updated evaluation of the Little Powder River to verify the impairment status relative to siltation.

Siltation is generally a cause of impairment for aquatic life because of the degradation of habitat for spawning fish, macroinvertebrates, and algae. There are several sources of siltation impairments including excess sediment loading, irregular flows, diversions, and other stream modifications.

Bed material was sampled in the Little Powder River at USGS station 06324970 in Wyoming. Between 1975 and 1981, the majority of the bed material at this site was fine- to medium-sized gravel (4–16 mm diameter). On average, only 35 percent of the bed material at this site was sand-sized or smaller (less than 2 mm in diameter) (Figure 3-53). Bed material sampling was performed once in 1998. During this sampling period, 100 percent of the bed material was less than 2 mm in size. Also, 85 percent of the bed material was clay and silt (less than 0.062 mm). This large shift in bed material from gravel (1975–1981) to clay and silt (1998) may indicate an impairment because of siltation. However, the degree to which natural channel formation is affecting the embeddedness of the river is unknown.

A final water quality impairment determination will not be made for siltation because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

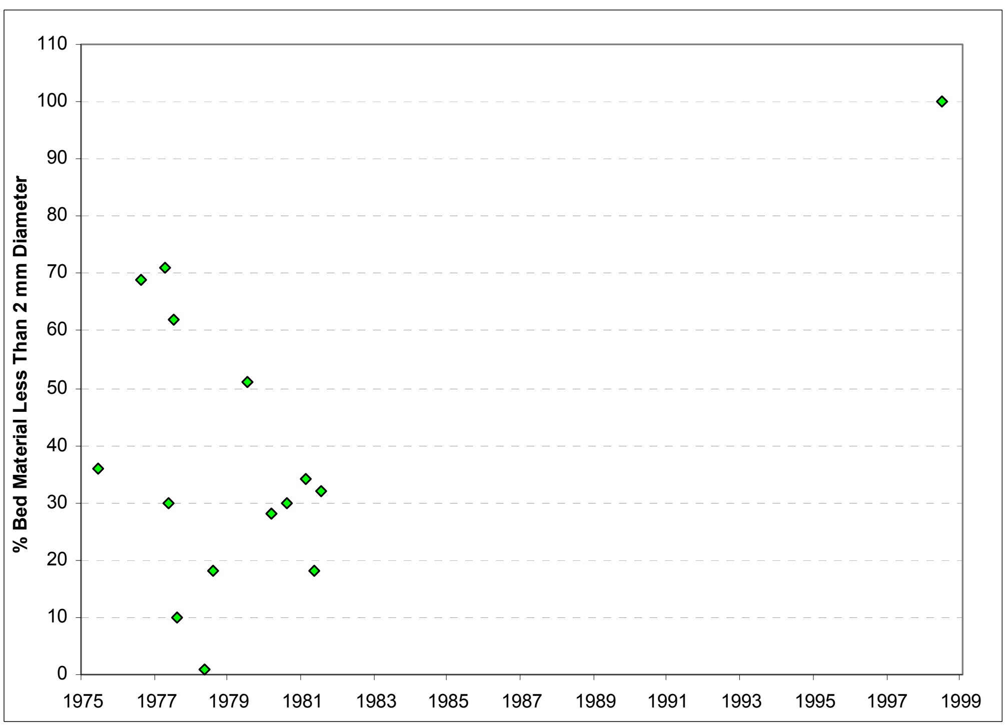

Figure 3-53. Bed material size at station 06324970, Little Powder River, Wyoming.

3.3.2.3.8 Water Quality Impairment Status: Little Powder River

The Montana 1996 303(d) list reported that the Little Powder River was impaired because of salinity/TDS/chlorides, flow alteration, other inorganics, siltation, and suspended solids. In 2002, the Montana 303(d) list reported that beneficial uses in the Little Powder River were not assessed because of insufficient credible data. The 1996 causes of impairment were analyzed in the previous sections to determine which causes will require TMDLs. Water quality impairment determinations could not be made for several causes of impairment because appropriate site-specific numeric criteria have not been identified, or because there was a lack of recent data. A summary for each evaluated cause of impairment for each segment of the Little Powder River is shown in Table 3-55.

Table 3-55. Water quality impairment status summary, Little Powder River.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Little Powder River	Chlorides	✔		No
	Flow alteration	✔		No
	Other inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Siltation	✔		Undetermined
	Suspended solids	✔		Undetermined
	Total dissolved solids	✔		Undetermined

3.4.3 Stump Creek

The Montana 1996 303(d) list reported that aquatic life uses in Stump Creek were impaired because of suspended solids (MDEQ, 1996). Beneficial uses were not evaluated for the 2002 303(d) list because of insufficient credible data. At the time of this report, no water chemistry, macroinvertebrate, or periphyton data were identified for Stump Creek. An aerial assessment of the Powder River watershed performed by the NRCS indicated that Stump Creek had stable bank slopes and little human alteration. The beneficial use support status for Stump Creek could not be determined at this time because of a lack of data.

3.4.4 Mizpah Creek

Figure 3-54 shows the general location of Mizpah Creek. The Montana 1996 303(d) list reported that Mizpah Creek was impaired because of organic enrichment/low DO, other inorganics, and suspended solids (MDEQ, 1996). Agricultural, aquatic life, fishery, recreation, swimmable, and drinking water beneficial uses were impaired by these causes in 1996. The Montana 2002 303(d) list reported that Mizpah Creek was fully supporting aquatic life and fishery uses. No other beneficial uses were evaluated for the 2002 report because of insufficient credible data.

3.4.4.1 Macroinvertebrates and Periphyton

Periphyton sampling at four sites in Mizpah Creek (1999–2000) indicated that it is supporting aquatic life uses in the upstream portions (stations UMC-1, UMC-2, LMC-1) but not in the downstream portions (station LMC-7) (Bahls, 2000, 2001). In 1999 and 2000, station UMC-1 was fully supporting aquatic life uses with a minor impairment due to organic loading (Figure 3-54). The other upstream stations were also fully supporting uses in 1999. Station LMC-7 is partially supporting aquatic life uses due to organic loading and sedimentation. However, Bahls noted that lentic conditions exist in Mizpah Creek and organic loading may be caused by ponding and stagnation that occurs at these sites. The overall composition at LMC-7 indicates some brackish water tendencies, moderate sedimentation, and moderate organic loading.

Macroinvertebrate sampling in Mizpah Creek found that water quality conditions deteriorate from upstream to downstream. Three sites (UMC-1, UMC-2, LMC-1) in the upstream portions of Mizpah Creek were partially supporting aquatic life uses (Bollman, 2000, 2001b). The most downstream station in 1999, LMC-7, had severe aquatic life impairment. Water quality violations and channelization were also noted at this site. The possible causes of impairment were nutrients, salinity, and temperature. Bollman noted that there was a severe decline in biotic health at UMC-1 and LMC-7 from 1999 to 2000. The most downstream station in 2000, MZ-2, had partial impairment of aquatic life uses.

Bollman also inventoried habitat conditions during macroinvertebrate sampling (Bollman, 2000, 2001b). Riparian zone habitat was suboptimal at two stations, and overall channel flow status was marginal or poor. Lentic conditions were present throughout Mizpah Creek during the sampling period.

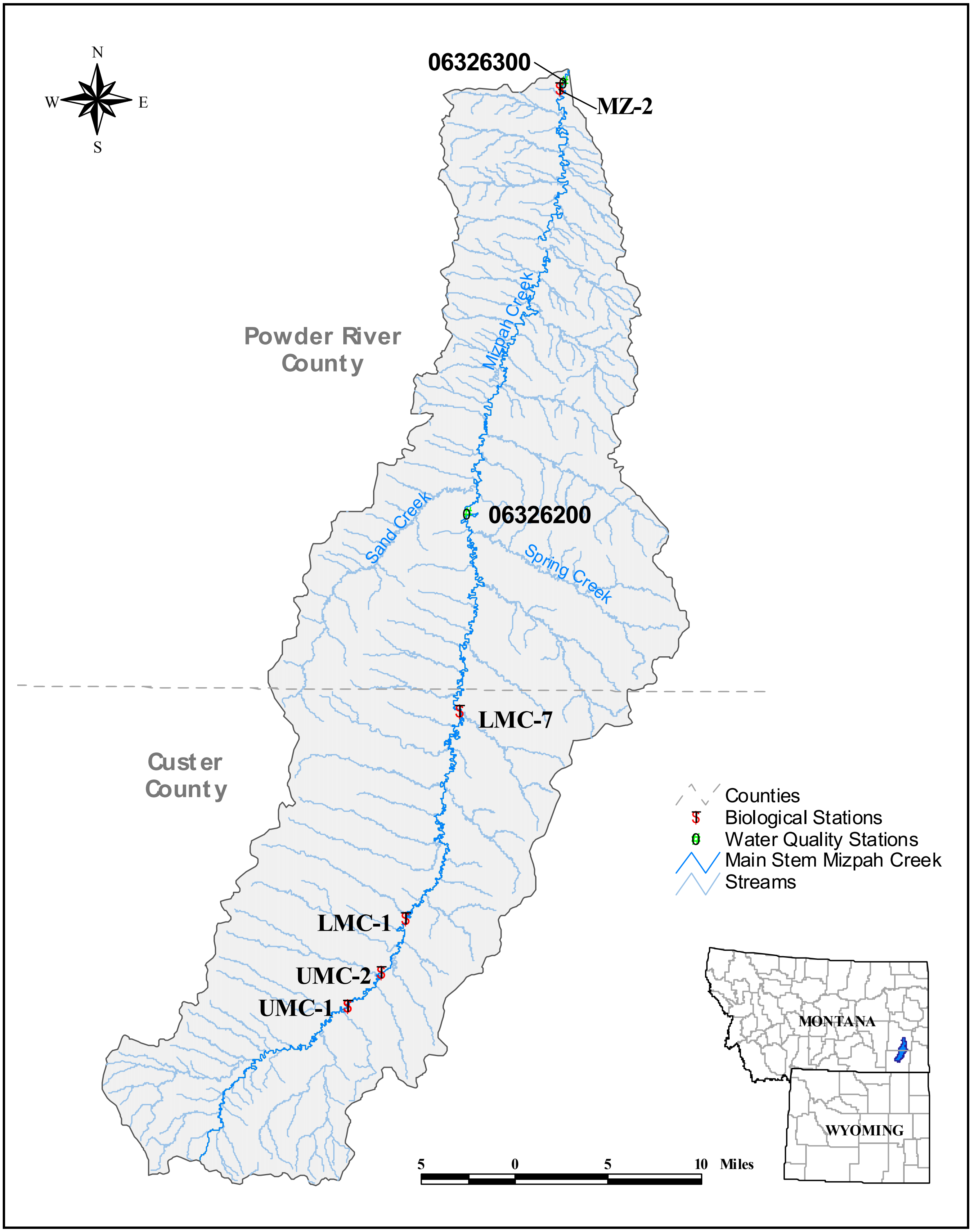

Figure 3-54. Mizpah Creek watershed and monitoring stations.

3.4.4.2 Fish

No recent fish data were available at the time of this report.

3.4.4.3 Water Chemistry Assessment

Water chemistry data for Mizpah Creek are available from two monitoring stations in Montana (Figure 3-54). These data were collected by USGS and are summarized in the following sections. Data collected by MDEQ in 2000 were unavailable at the time of this report, but will be included in the final TMDL analysis. The most recent USGS sampling was in 1989.

3.4.4.3.1 Salinity

Mizpah Creek was not listed as impaired for salinity on the 1996 303(d) list. Agricultural uses in Mizpah Creek were not evaluated for the 2002 303(d) list, and salinity was not identified as a cause of impairment for other uses. This section presents an updated evaluation of Mizpah Creek to verify the impairment status relative to salinity.

EC data are summarized in Table 3-56 and are compared to standards in Table 3-57. There are no recent USGS salinity data for Mizpah Creek. Historical data show that average EC values were often more than three times the proposed standards (Figure 3-55). Also, 100 percent of the growing season EC values exceeded proposed salinity standards. No total dissolved solids (TDS) or chloride data were available for Mizpah Creek at the time of this report.

A final water quality impairment determination will not be made for salinity (EC) until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-56. Summary of EC data, Mizpah Creek (µS/cm).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Non-growing Season (November 1–March 31)							
6326200	12	3,093	2,720	3,900	11%	4/13/76	5/18/89
6326300	80	2,028	520	4,450	56%	10/17/75	6/27/89
Growing Season (April 1–October 31)							
6326200	9	2,870	1,370	3,900	27%	11/13/75	3/1/77
6326300	60	1,944	162	5,010	72%	11/13/75	11/7/89

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-57. Summary of EC exceedances, Mizpah Creek.

Season	Salinity Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season	500	92	92	100%	0	0	0%
Non-growing Season	2,000	69	37	54%	0	0	0%

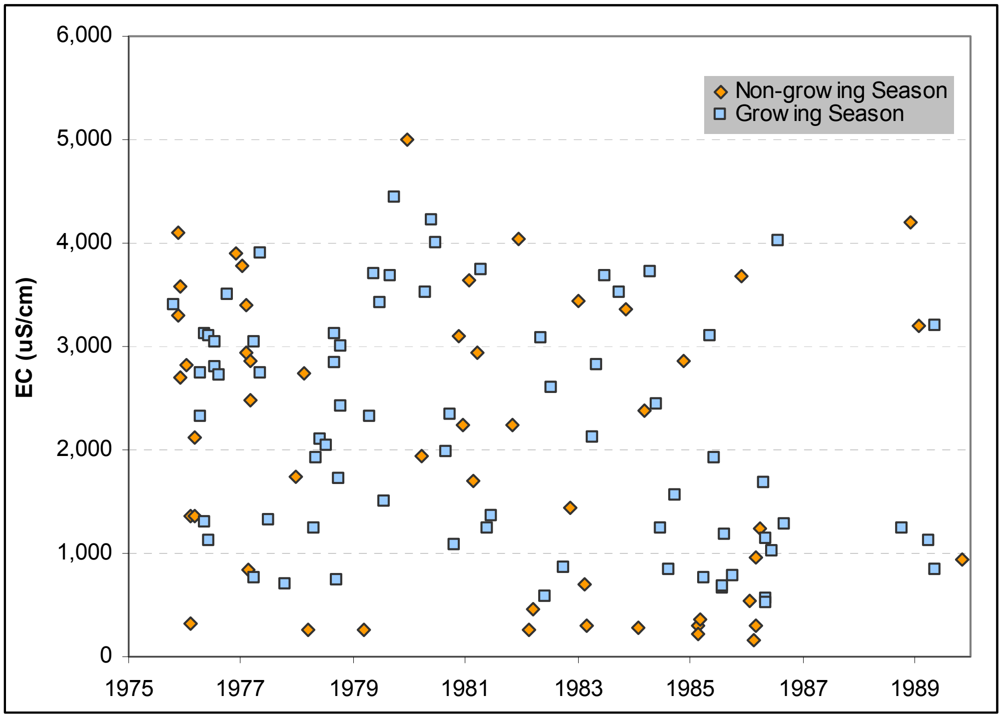

Figure 3-55. EC data for Mizpah Creek (all stations).

3.4.4.3.2 SAR

Mizpah Creek was not listed as impaired for SAR on the 1996 303(d) list. Agricultural uses in Mizpah Creek were not evaluated for the 2002 303(d) list, and SAR was not identified as a cause of impairment for other uses. This section presents an updated evaluation of Mizpah Creek to verify the impairment status relative to salinity.

SAR data for Mizpah Creek are summarized in Table 3-58. The data are compared to MDEQ's proposed SAR criteria in Table 3-59. There are no recent USGS SAR data for Mizpah Creek. Historically, SAR appears to have impaired agricultural uses (Figure 3-56).

A final water quality impairment determination will not be made for SAR until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-58. Summary of SAR data, Mizpah Creek.

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Non-growing Season (November 1–March 31)							
6326200	9	7.3	6.0	8.0	10%	11/13/75	3/1/77
6326300	21	12.1	2.0	24.0	51%	11/13/75	3/17/82
Growing Season (April 1–October 31)							
6326200	10	8.5	7.0	10.0	14%	4/13/76	10/18/78
6326300	33	13.8	6.0	25.0	41%	10/17/75	7/22/82

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-59. Summary of SAR exceedances, Mizpah Creek.

Samples	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
All Data	73	69	95%	0	0	0%
Data with Paired SAR and Salinity	63	59	94%	0	0	0%

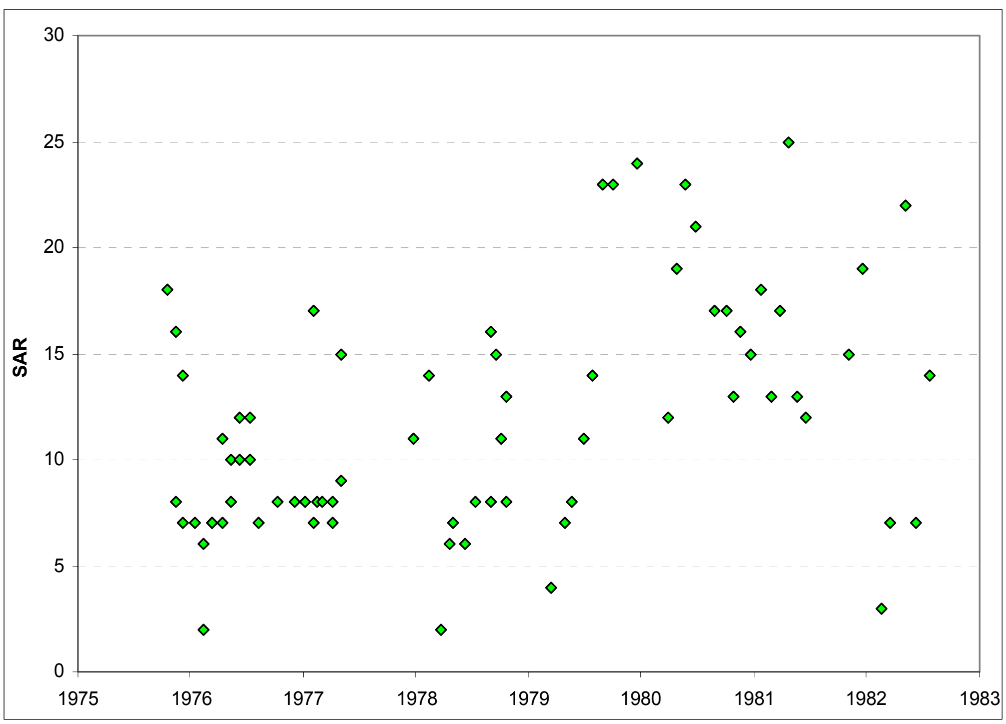

Figure 3-56. SAR data for Mizpah Creek (all stations).

3.4.4.3.3 Organic Enrichment/ DO

Mizpah Creek was listed as impaired for organic enrichment/DO on the 1996 303(d) list. Aquatic life and fishery beneficial uses were fully supported for the 2002 303(d) list, and organic enrichment/DO was not identified as a cause of impairment for other uses. This section presents an updated evaluation of Mizpah Creek to verify the impairment status relative to organic enrichment/DO.

There are no recent USGS nutrient or DO data for Mizpah Creek (Table 3-60). An analysis of data showed that only two samples in 15 years were below the 5.0 mg/L minimum (Figure 3-57). No USGS chlorophyll-*a* data were available for Mizpah Creek. Recent periphyton and macroinvertebrate data suggest that excessive nutrient loading is present in the stream. However, it was noted that this organic loading might be due to natural loadings from lentic conditions (Bahls, 2000, 2001).

A final water quality impairment determination will not be made for organic enrichment/DO because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

Table 3-60. Summary of DO data, Mizpah Creek.

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
6326200	18	8.0	3.0	12.0	28%	11/13/75	5/18/89
6326300	74	9.9	5.2	13.2	21%	10/17/75	11/7/89

[a]CV – Coefficient of Variation (standard deviation/mean).

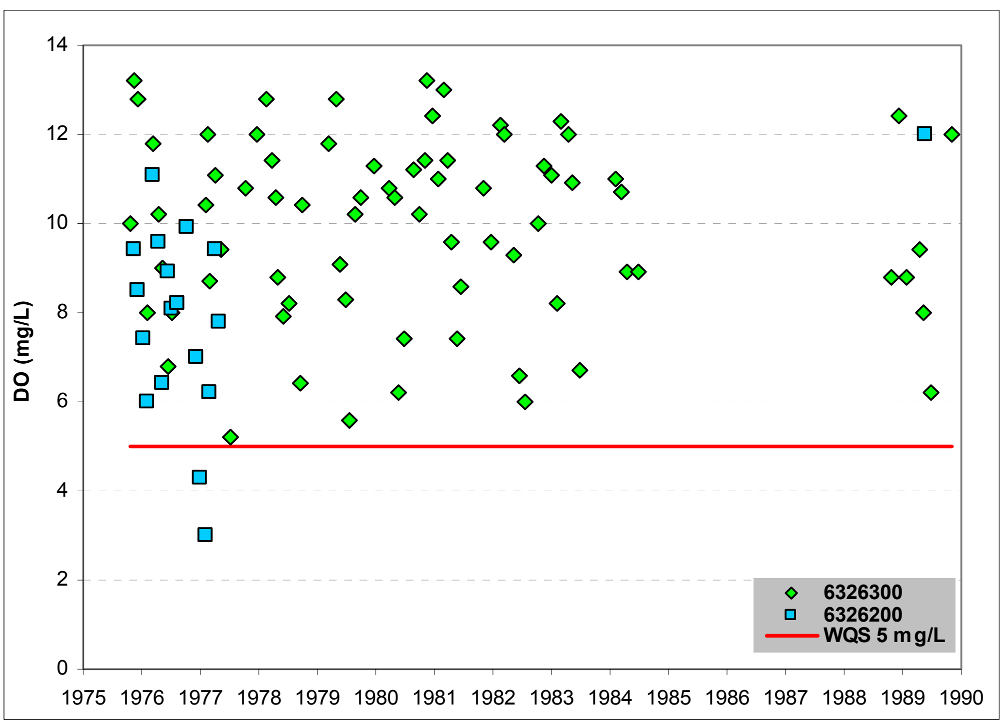

Figure 3-57. DO data for Mizpah Creek (all stations).

3.4.4.3.4 Total Suspended Solids

Mizpah Creek was listed as impaired for total suspended solids (TSS) on the 1996 303(d) list. Aquatic life and fishery beneficial uses were fully supported for the 2002 303(d) list, and TSS was not identified as a cause of impairment for other uses. This section presents an updated evaluation of Mizpah Creek to verify the impairment status relative to TSS.

There are no numeric water quality standards for TSS in Montana, and no reference conditions are available for Mizpah Creek at this time. Both Utah and South Dakota have a TSS criterion of 90 mg/L for the protection of warmwater fishery streams, and South Dakota also has a criterion of 150 mg/L for the protection of marginal warmwater fishery streams. The 90 mg/L and 150 mg/L criteria were compared to the TSS data from Mizpah Creek to provide some insight on use impairment status. However, a better target for prairie streams is needed to make more conclusive decisions. Others have indicated that high turbidity and sandy substrates are essential components for the organisms adapted to survive in Mizpah Creek (Clancey, 2002).

TSS data are summarized in Table 3-61 and data are shown in Figure 3-58. There was a wide range in the TSS concentrations sampled from Mizpah Creek and the coefficient of variations at both stations were high. Over 50 percent of the TSS data exceeded the 90 mg/L target (Table 3-62). Recent periphyton and macroinvertebrate sampling indicated that sediment was impairing aquatic life uses in Mizpah Creek (Bahls, 2000, 2001; Bollman, 2000, 2001b).

A final water quality impairment determination will not be made for suspended solids because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes.

Table 3-61. Summary of TSS data, Mizpah Creek.

Station	Count	Median	Average	Min	Max	CV[a]	Min Date	Max Date
6326200	17	61	82	12	385	106%	11/13/75	5/3/77
6326300	67	158	1,897	23	18,400	206%	10/17/75	6/27/84

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-62. Summary of TSS exceedances, Mizpah Creek.

Target	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
90 mg/L	84	53	63%	0	NA	NA
150 mg/L	84	39	46%	0	NA	NA

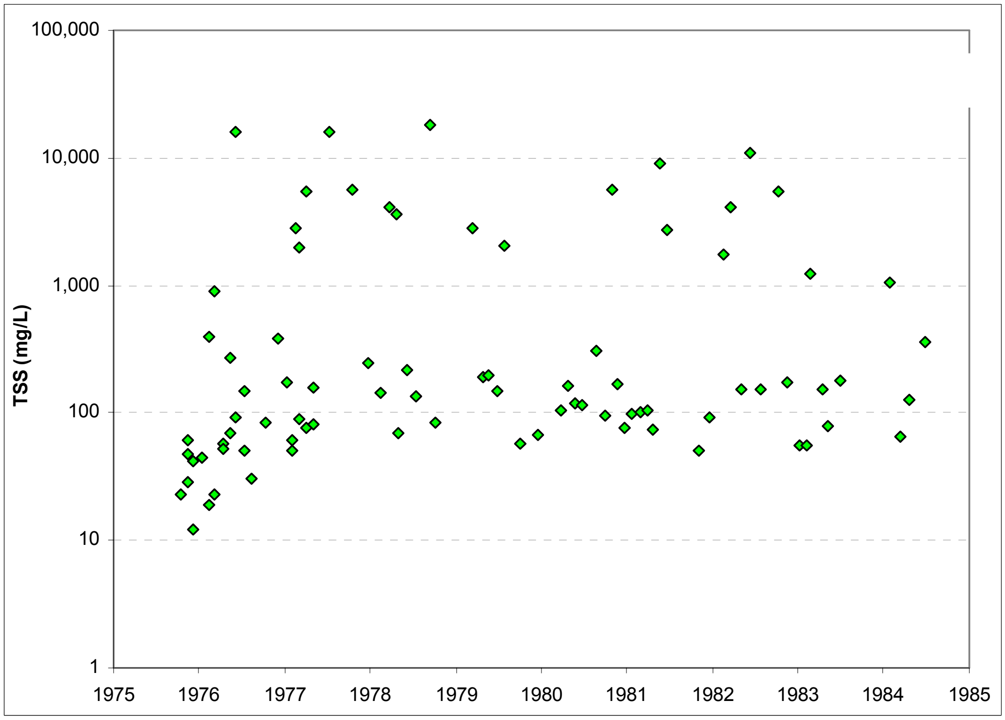

Figure 3-58. TSS data for Mizpah Creek (all stations).

3.4.4.3.5 Other Inorganics (Sulfate)

As described in Section 3.4.4, Mizpah Creek was listed as impaired for other inorganics (sulfates) on the 1996 303(d) list. Agricultural uses in Mizpah Creek were not evaluated for the 2002 303(d) list, and sulfate was not identified as a cause of impairment for other uses. This section presents an updated evaluation of Mizpah Creek to verify the impairment status relative to sulfates. EPA has a sulfate secondary drinking water standard of 250 mg/L. Several states (North Dakota, New Mexico, South Dakota, Utah) have chosen statewide or site-specific sulfate standards of 250, 500, or 750 mg/L.

Table 3-63 summarizes the sulfate data for Mizpah Creek. Sulfate concentrations were generally much higher than the secondary drinking water standard of 250 mg/L. Several samples exceeded the calculated TDS targets for the Powder River (Figure 3-59).

A final water quality impairment determination will not be made for sulfate until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2).

Table 3-63. Summary of sulfate data, Mizpah Creek (mg/L).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Non-growing Season (November 1–March 31)							
6326200	9	999	470	1,300	24%	11/13/75	3/1/77
6326300	30	685	36	1,900	74%	11/13/75	11/7/89
Growing Season (April 1–October 31)							
6326200	11	1,209	1,000	1,400	10%	4/13/76	5/18/89
6326300	45	792	170	1,700	56%	10/17/75	6/27/89

[a]CV – Coefficient of Variation (standard deviation/mean).

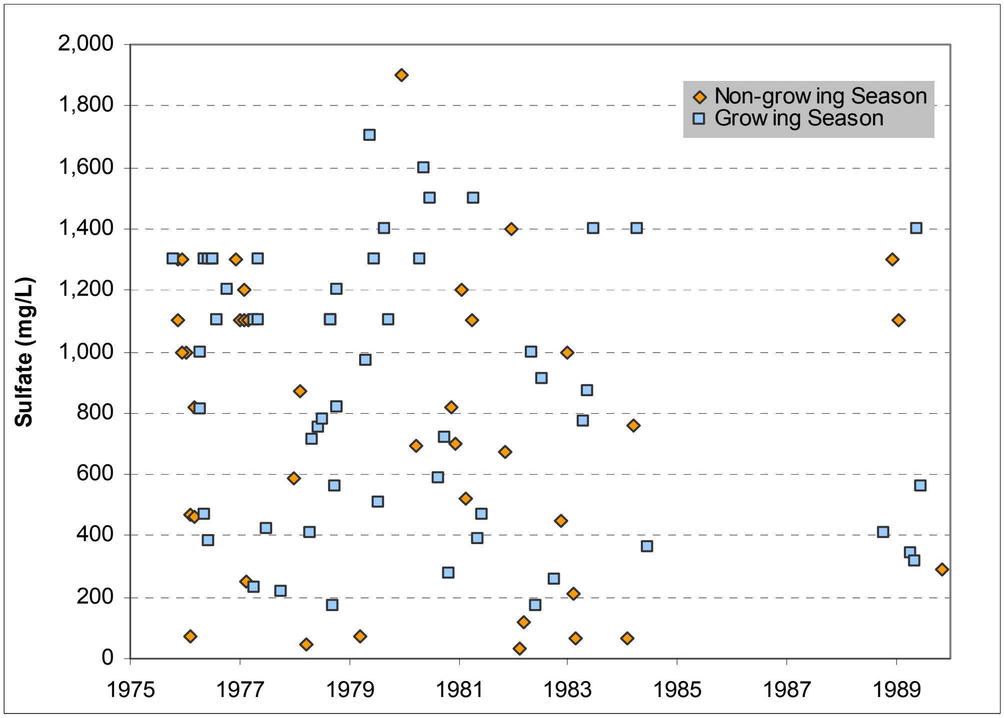

Figure 3-59. Sulfate data for Mizpah Creek (all stations).

3.4.4.3.6 Water Quality Impairment Status: Mizpah Creek

The Montana 1996 303(d) list reported that Mizpah Creek was impaired because of organic enrichment/low DO, other inorganics, and suspended solids. In 2002, using additional data and a new listing methodology, MDEQ reported that Mizpah Creek had no causes of impairment. Aquatic life and fishery uses were fully supported in Mizpah Creek. Other beneficial uses (recreation, drinking water, agricultural, and industrial uses) were not evaluated for the 2002 report because of insufficient credible data. Narrative information from the 2000 Montana Section 303(d) list summary spreadsheet is shown below.

Aquatic life and fishery beneficial use support determinations were based primarily on available habitat info, the entire stream fully supports aquatic life. One or two problems may be significant. According to Tom Pick and Warren Kellogg, the presence of numerous spreader dikes apparently results in less scouring within the channel and possibly reduced pool depths. The low biological integrity measured at LMC-7 appears to be due, in part, to high natural organic loading rates. However, the spreader dikes present increase infiltration and soil leaching which may cause the higher concentrations of sulfate and some other parameters measured at LMC-7. According to Tom Pick of the NRCS, the number of spreader dikes on Mizpah Creek and its tributaries may have increased between the 1970s and the present. This, in turn, may be a cause of potentially increased salinity through time as indicated by limited sampling results. These issues should be revisited when more information is available. The pre-1999 data show some potentially high metals concentrations. However, the older data are of limited value due to high reporting limits, poor data quality, age of data, and lack of an adequate reference condition. (MDEQ, 2002b).

The 1996 causes of impairment were analyzed in the previous sections to determine which causes will require TMDLs. Water quality impairment determinations could not be made for several causes of impairment because appropriate site-specific numeric criteria have not been identified, or because there was a lack of recent data. A summary for each evaluated cause of impairment is shown in Table 3-64.

Table 3-64. Water quality impairment status summary.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Mizpah Creek	Chlorides			Undetermined
	Organic enrichment/DO	✔		Undetermined
	Other inorganics	✔		Undetermined
	Salinity			Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	Total dissolved solids			Undetermined

[a]Not all causes of impairment were evaluated.

4.0 CONCEPTUAL MONITORING PLAN

The purpose of this section is to identify data gaps and recommend additional monitoring strategies for the Powder River watershed. The goals of the additional monitoring are to determine beneficial use impairments, obtain data for setting up and calibrating a watershed/water quality model, and better determine sources of impairment. The amount of current, reliable data is directly linked to the level of confidence in the results of the TMDL process. The more data that can be collected, the easier it will be to determine the current impairment status, appropriate water quality targets, and existing and allowable loadings for the Powder River watershed. The monitoring plan presented below is a *conceptual plan* and provides a preliminary framework for the final monitoring strategy. A more detailed sampling and analysis plan is being prepared.

4.1 Identified Data Gaps

4.1.1 Beneficial Use Determinations

Section 3.0 summarized all available data relative to the water quality limited segments identified on the 1996 303(d) list. In many cases, insufficient data were available to make final water quality impairment determinations. The identified data gaps are summarized in Table 4-1. The purpose of this monitoring section is to develop a detailed strategy to fill these gaps.

Table 4-1. Identified data gaps in the Powder River watershed.

Waterbody	Pollutant	Identified Data Gap
Powder River	Salinity/TDS/Chlorides	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	SAR	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	TSS	• Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions
	Other Inorganics (Sulfate)	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	Nutrients	• Insufficient data to define the natural conditions • Lack of comparable reference condition or suitable target
	Metals	• None
	Pathogens	• None
Little Powder River	Salinity/TDS/Chlorides	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	SAR	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	Other Inorganics (Sulfate)	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	TSS	• Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions
	Siltation	• Insufficient data to define the natural conditions • Lack of comparable reference condition or suitable target • Lack of recent data
Mizpah Creek	Salinity/TDS/Chlorides	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data

Waterbody	Pollutant	Identified Data Gap
	SAR	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
	Organic Enrichment/Low DO	• Insufficient data to define the natural conditions • Lack of comparable reference condition or suitable target • Lack of recent data
	Other Inorganics (Sulfate)	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
	TSS	• Lack of recent data • Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions
Stump Creek	Salinity/TDS/Chlorides	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
	SAR	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
	TSS	• Lack of recent data • Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions

4.1.2 Model Calibration

As discussed in Section 1.3.2, it is expected that during Phase III some sort of watershed and water quality modeling will need to be performed to establish the relationship between the in-stream water quality targets and the source loadings. Using models allows for the evaluation of management options and the selection of the option that will achieve the desired source load reductions in the most efficient manner. Although a specific model has not yet been identified, one of the purposes of the data collection activities will be to collect the data that are necessary to setup, apply, calibrate, and validate the model. The data that will likely be needed to setup and calibrate whichever model is chosen include the following:

- Hourly precipitation and temperature data for representative areas of the watershed.
- Flow data at multiple main stem and tributary stations for hydrologic calibration and validation of the model.
- Stream cross sections for the upstream, middle, and downstream segments of the Powder River.
- Water quality data at multiple main stem and tributary stations to calibrate the model. Additional data will be necessary at the same stations for model validation.
- Sampling of significant sources, such as mining, oil and gas development, and irrigation return flows, to better characterize these sources within the model.
- Shallow groundwater sampling to characterize the interaction between groundwater and surface waters.

4.1.3 Source Assessment

TMDLs must consider all significant sources of a pollutant (e.g., the source of excessive algal growth in a stream are nutrients from a municipal wastewater treatment plant and an animal feeding operation). It is necessary to identify and quantify the relative contribution from all potentially significant sources for each pollutant. A summary of the listed pollutants and their associated potential sources in the Powder River watershed is provided in Table 4-2. To date, little work has been conducted in the Powder River watershed to identify and estimate loading rates from those pollutants appearing on the 1996 303(d) list.

Table 4-2. Pollutants and their potential sources in the Powder River watershed.

Water Body	Pollutant	Potential Sources
Powder River	Salinity/TDS/Chlorides	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	SAR	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Suspended Solids	• Agriculture • Channel erosion and scouring • Natural sources (geology and soils) • Pasture/range grazing
	Metals	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Nutrients	• Animal feeding operations • Agriculture • Fisheries • Recreation • Wastewater disposal
	Other Inorganics (Sulfate)	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Pathogens	• Industrial point sources • Septic systems
Little Powder River	Salinity/TDS/Chlorides	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	SAR	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Siltation	• Natural sources (geology, soils) • Channel erosion and scouring • Agriculture • Pasture/range grazing
	Suspended Solids	• Agriculture • Channel erosion and scouring • Natural sources (geology and soils) • Pasture/range grazing
	Other Inorganics (Sulfate)	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)

Water Body	Pollutant	Potential Sources
Mizpah Creek	Salinity/TDS/Chlorides	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	SAR	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Organic Enrichment/Low DO	• Animal feeding operations • Agriculture • Fisheries • Recreation • Wastewater disposal
	Other Inorganics	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	TSS	• Natural sources (geology, soils) • Channel erosion and scouring • Agriculture
Stump Creek	Salinity/TDS/Chlorides	• Natural sources (geology, soils, evaporation) • Irrigation • Mining, oil, and CBM development
	Suspended Solids	• Agriculture • Channel erosion and scouring • Natural sources (geology and soils) • Pasture/range grazing

4.2 Monitoring Strategy

There are four types of data that need to be collected for the 2003 sampling program:

- Data for listed segments and parameters where there are no current data
- Data to quantify sources in the Powder River and tributaries
- Data to assess the natural or background conditions of the listed parameters
- Data to run and calibrate a model

All four types of data will help to make beneficial use determinations for the listed segments and to develop TMDLs for those segments that are indeed impaired. This report assumes that USGS will continue monitoring water quality and flow at stations 06324500 and 06326500 in the Powder River, and station 06325550 in the Little Powder River. The following sections outline the additional monitoring sites and needed data.

4.2.1 Data Gap – No Current Data

4.2.1.1 Tributaries

There are few current data for tributaries in the Powder River watershed, specifically for Mizpah Creek and Stump Creek. However, data exist at historic USGS stations throughout the watershed. Salinity (EC), SAR, TDS, DO, turbidity, metals, and TSS data should be collected at or near these historic USGS monitoring sites so that current data (2003) can be compared to the historic data. Metals samples should be collected and analyzed using standard USEPA procedures to obtain the highest levels of quality, accuracy, and precision. Instantaneous flows should be obtained at the time of any sampling. Biological assemblages (macroinvertebrates, fish, algae) should be sampled at these sites as well. Because there are no historic sites in the Stump Creek watershed, new sampling sites need to be established.

4.2.1.2 Powder River

There are varying types and amounts of data at stations in the Powder River. In general, additional recent data are needed to fill data gaps and better characterize the river. Sampling in 2003 should occur at historic USGS monitoring sites so that historic data and current data can be compared. Sampling parameters should include nutrients (phosphorus and nitrogen), chlorophyll-*a*, salinity (EC), chlorides, sulfate, SAR, TDS, DO, turbidity, TSS, fecal coliforms, *Escherichia coli,* and metals. Recommended metals sampling includes arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, silver, and zinc. Recommended monitoring sites are shown in Table 4-3 and Figure 4-1.

Table 4-3. 2003 Metals sampling sites for the main stem of the Powder River.

USGS Site Number	Site Name	Latitude	Longitude
06326520	Powder River at the mouth near Terry, MT	46.7375	-105.4286
06326500	Powder River near Locate, MT	46.4300	-105.3094
06326000	Powder River near Mizpah, MT	46.2500	-105.2667
06325650	Powder River near Powderville, MT	45.7522	-105.0875
06324710	Powder River at Broadus, MT	45.4269	-105.4014
06324500	Powder River at Moorhead, MT	45.0678	-105.8694
06317000	Powder River at Arvada, WY	44.6500	-106.1269

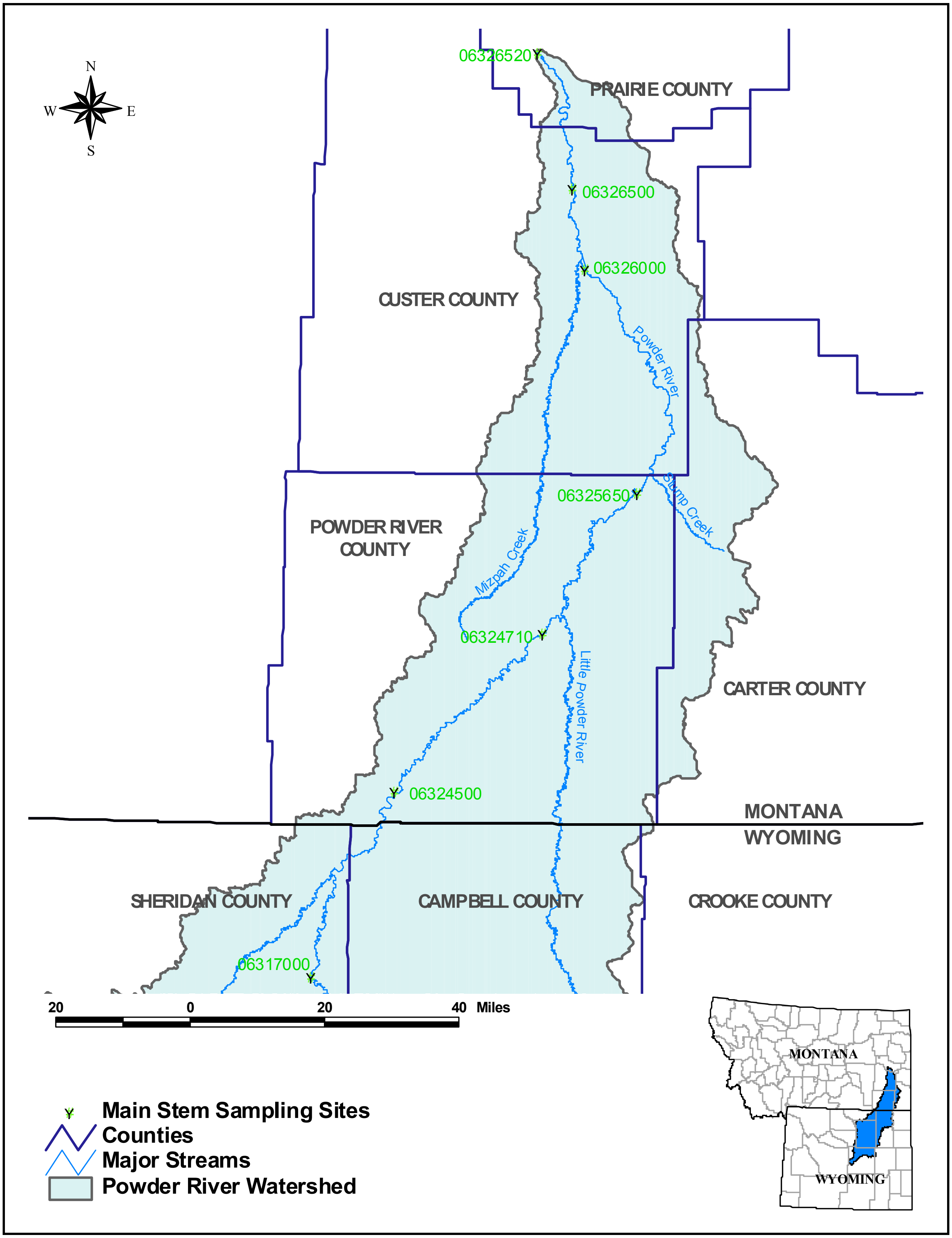

Figure 4-1. 2003 Main stem sampling sites for the Powder River.

4.2.2 Data Gap – Sources

There are few data or studies assessing potential sources of impairment in the Powder River watershed. Potential sources of impairment are irrigation, grazing, animal feeding operations, fisheries, channel erosion, natural sources, industrial sources, and mining/oil/CBM operations. A monitoring approach for quantifying the effect of these sources is outlined below.

- Identify and monitor major irrigation return flows for flow and water chemistry
- Identify and monitor upstream and downstream of major agricultural areas
- Monitor shallow groundwater aquifers for water chemistry
- Monitor downstream of major mining, oil, and gas development activities
- Monitor downstream of major wastewater discharges (treatment plants and areas with high septic system densities)
- Monitor instream erosion using the Bank Erosion Hazard Index (BEHI) methodology

The following sections describe the monitoring approach to help locate and quantify major sources of impairment in the Powder River watershed.

4.2.2.1 Irrigation Return Flows

Irrigation return flows are a potential source of contaminants and little data are available. Irrigation returns should be identified and monitored for quality and quantity. Returns from different irrigation practices, soil types, and crops should be monitored. Examples include returns from flood irrigation, spreader dike systems, and sprinkler based systems. The NRCS Phase 1 Rapid Aerial Assessment identified major irrigation return flows (Figure 4-2). Each site should be evaluated in the field to determine which sites should be monitored, and monitoring sites should be selected based on site-specific conditions. Other irrigation return flows should be identified as well. The monitoring approach is outlined below.

- Identify all irrigation return flows during a field assessment
- Identify sites with different irrigation practices, soils, and crops
- Locate appropriate water chemistry sampling sites
- Obtain permission from the landowners for sampling
- Perform water chemistry sampling (EC, TDS, SAR, and chlorides) and obtain flow data

Several irrigation return flow sites should be monitored in the Powder River watershed to determine the salinity contribution from a variety of different conditions. The sites should be monitored during the growing season and specifically after periods of irrigation if possible. All possible irrigation returns should also be identified to quantify the total load contributed by irrigation. Shallow groundwater wells should be identified and monitored where available.

4.2.2.2 Mining

There is currently not a good understanding of how mining, oil, and gas development affect water quality in the Powder River. Also, the location of many of these sites is unknown. The first step to developing a monitoring plan to address these potential sources is to identify all mining-related sources, source types, and locations. Monitoring at or near the potential sources of pollution should occur for EC, TDS, SAR, and chlorides.

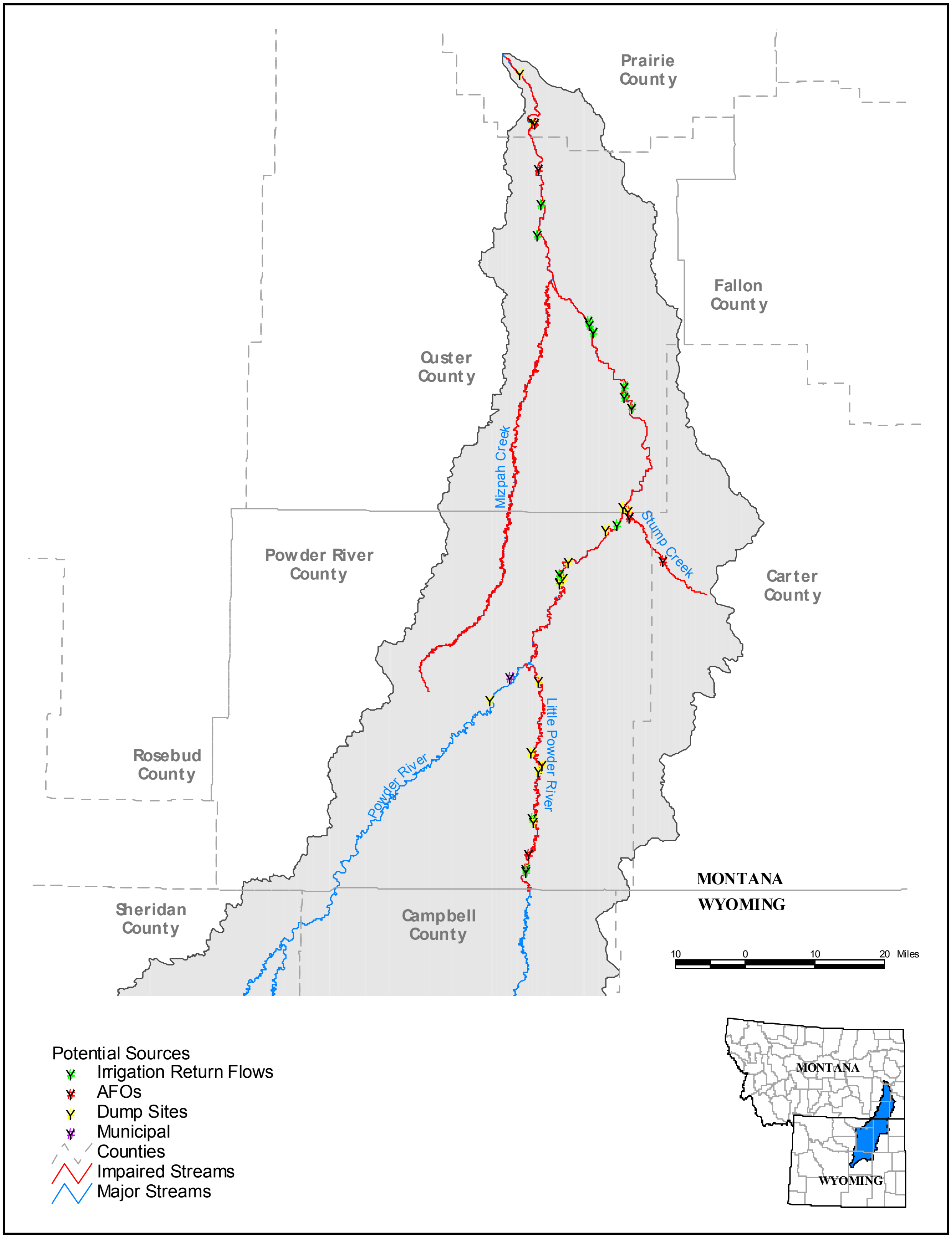

Figure 4-2. Potential sources identified by NRCS.

4.2.2.3 Streambank Erosion

Streambank erosion is a potential source of sediment in the Powder River. Several methods exist for measuring and predicting streambank erosion depending on the measured amount of erosion over time and bank stability factors. One such technique is the bank erosion hazard index (BEHI). BEHI measurements should be made along similar reaches of the main stem of the Powder River and the major tributaries. An approach for quantifying sediment loads from streambank erosion is outlined below.

- Identify unique segments of the Powder River based on streambanks by rafting or walking portions of the river.
- Partition the river into several similar segments based on the assessment.
- Perform a BEHI measurement for each segment prior to the spring snowmelt season.
- Install bank erosion pins at each BEHI location during the initial BEHI measurement.
- Measure streambank erosion using the bank pins after the snowmelt season (July) and again in the fall (October).

By knowing the BEHI score and the total length of a segment, a total volume of sediment load from streambank erosion can be estimated. Pebble counts should also be performed to determine size of bed material in the channel. This should be performed during the July and October sampling periods. An aerial photograph analysis could also help to quantify streambank erosion and channel movement.

4.2.2.4 Other Potential Sources

Other potential sources, such as industrial and municipal sources, should be identified during a field assessment of the Powder River watershed. If it is suspected during the field assessment that the potential source is contributing a significant amount of pollution to the river, it should be monitored as part of the 2003 monitoring plan.

4.2.3 Data Gap – Background Conditions

4.2.3.1 Reference Streams

Reference streams are used to compare data from a less-impaired stream to an impaired stream of concern. This is extremely helpful for determining beneficial use impairments for parameters that have no numeric standards (e.g., nutrients, TSS, TDS, chlorides). The reference stream should have few sources or causes of impairment and it should be relatively similar in size, type, and region to the target stream. It is unlikely that a reference stream could be found for the main stem of the Powder River because of the unique conditions that occur in the watershed. However, reference streams for the impaired tributaries should be located and monitored. Reference streams outside of the Powder River watershed, but with similar watershed characteristics, may need to be found. A plan for identifying and monitoring reference streams is shown below.

- Perform a field assessment to identify reference streams for tributaries in the Powder River watershed. A reference stream outside of the watershed may need to be found, or a less-impacted portion of the target stream may be used.
- Sample water chemistry at both the reference and target streams at similar time periods once per month during the non-growing season and twice per month during the growing season.
- Monitor fish, macroinvertebrate, and algae communities at both streams at least once per year.

Sampling at both the reference stream and the target stream should be performed at similar intervals and time periods, which would allow for statistical comparisons. The establishment of these reference streams will have to be a site-specific process with a detailed investigation of the watershed. Reference streams for Mizpah Creek, Little Powder River, and Stump Creek should be established.

4.2.3.2 Continuous Data Monitoring

A data probe, such as a YSI or Hydrolabs sensor, can be used to obtain continuous samples at small specified intervals (e.g., hourly). Data probes generally come with sensors to obtain DO, temperature, turbidity, and EC data. Data from these sensors would help to characterize the water chemistry of the river on a daily basis, and the data would supplement ambient sampling by USGS and MDEQ.

A continuous sample data probe is recommended for the main stem of the Powder River. The probe would obtain hourly readings for EC, turbidity, and DO. The continuous readings would provide information on conditions during low and high-flow events, which can be used for multiple reasons such as setting up and calibrating a model, and obtaining information on background conditions. The probes should be installed at or near current USGS flow gages to ensure that accurate flow readings accompany the data. A continuous data probe for salinity (EC) is currently in place at USGS station 06324500 (Powder River at Moorhead, Montana). Other recommended sites are 06326500 and 06317000, and continuous flow should be monitored at these gages during the sampling period of the data probe. Also, periodic TSS and TDS concentrations should be sampled at these sites so that relationships can be developed between turbidity and sediment, and EC and TDS.

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APPENDIX A: MAJOR LAND RESOURCE AREAS DATA DESCRIPTION

43--Northern Rocky Mountains
Idaho, Montana, Oregon, Washington, and Wyoming

Land use: Nearly all this area is federally owned and administered by the Forest Service, U.S. Department of Agriculture, and the BLM, Department of the Interior. Most of the privately owned land is controlled by large commercial timber companies. All the forested areas are used as wildlife habitat, for recreation and watershed, and for timber production. Meadows on the upper mountain slopes and crests above timberline provide summer grazing for livestock and big game animals. Mining is an important industry in Idaho and western Montana. Dairy and livestock farms are important enterprises in the west. Less than 2 percent of the area is cropped. Forage, grain, peas, and a few other crops are grown in some valleys.

Elevation and topography: Elevation is mainly 400 to 2,400 m, but it is almost 3,000 m on some mountain peaks. Some areas in Montana and Wyoming are at an elevation of 2,100 to 3,000 m, and mountain peaks are almost 4,300 m. High mountains having steep slopes and sharp crests are cut by narrow valleys, most of which have steep gradients. Lakes are common, especially in glaciated areas.

Climate: Average annual precipitation—625 to 1,525 mm, increasing with elevation, but almost 375 mm in the western part of the area and almost 2,550 mm in high mountains. Most of the precipitation during the fall, winter, and spring is snow. Summers are dry. Average annual temperature—2 to 7 °C in most of the area, but it is 8 °C or more at low elevations. Average freeze-free period—45 to 120 days, decreasing with elevation, and as long as 140 days in low valleys of Washington. Frost occurs every month of the year on high mountains; some peaks have a continuous cover of snow and ice.

Water: Moderate precipitation and many perennial streams and lakes provide ample water. Streams and reservoirs supply water to adjoining MLRAs for irrigation and other uses. Springs and shallow wells in the valleys provide water for domestic use and livestock. Elsewhere, groundwater supplies are small and mostly untapped.

Soils: Most of the soils are Ochrepts and Andepts. They have a frigid or cryic temperature regime. Shallow to moderately deep, medium-textured, and moderately-coarse textured Cryochrepts (Jughandle and Holloway series), and Xerochrepts (Waits and Moscow series) are on mountain slopes. Cryandepts (Huckleberry, Truefissure, and Coerock series) are on ridges with thin layers of volcanic ash. Stony Cryorthents (Tamely series) and areas of rock outcrop are on peaks and ridges above timberline. Detailed soil survey information is lacking in most of the area.

Potential natural vegetation: This area supports conifer forests. Forests of western white pine, ponderosa pine, lodgepole pine, western redcedar, western larch, hemlock, Douglas fir, subalpine fir, and spruce are common. Alpine grasses, forbs, and shrubs and scattered stands of subalpine fir, spruce, and whitebark pine grow on high mountains of Montana and Wyoming.

46--Northern Rocky Mountain Foothills
Montana and Wyoming

Land use: About one-fifth of this area is federally owned. The remainder is in farms and ranches. One-half or more of the area is a range of short and mid grasses and some shrubs. Many of the valleys are irrigated, but they make up only 1 or 2 percent of the total area. Grain and forage for livestock are the main crops, but potatoes, sugar beets, peas, and some other crops are grown in the warmer valleys. About one-fifth of this area, mainly along the northeastern side, is dryfarmed to wheat. Some of the highest hills are forested.

Elevation and topography: Elevation ranges from 1,100 to 1,800 m in the north increasing gradually to 1,800 or 2,400 m in the south and in central Wyoming. The rugged hills and low mountains are cut by many narrow valleys that have steep gradients. Broad flood plains and fans border a few of the major rivers.

Climate: Average annual precipitation—300 to 500 mm, but 750 mm at the highest elevations and 250 mm in some basins. In the north, minimum precipitation is in spring, and in the south it is early in summer. Winter precipitation is snow. Average annual temperature—6 to 7 °C. Average freeze-free period—90 to 125 days, but only 80 days at the highest elevations.

Water: Precipitation is too low for good growth of crops in some parts of the area, but in others it is adequate for grain farming and forage production. The major rivers provide most of the water for irrigation, but small streams furnish local supplies. Groundwater is abundant in the fill in some valleys, but in most of the area groundwater is meager or lacking.

Soils: Soils of this area are mostly Borolls, Orthents, and Fluvents. They are medium- to fine-textured and mainly well-drained and have a frigid temperature regime. Moderately deep to deep Argiborolls (Absarokee, Farnuf, and Savage series), Haploborolls (Winifred and Rottulee series), and Natriborolls (Adger series) are on sedimentary uplands, alluvial fans, foot slopes, and terraces. Shallow Argiborolls (Sinnigam and Amherst series), Haploborolls (Castner series), and Ustorthents (Cabba and Wayden series) are on sedimentary uplands. Deep, nearly level to gently sloping Ustifluvents (Havrelon and Lohler series) are on flood plains and low alluvial terraces. Soils in wooded areas are at higher elevations where more rainfall is received.

Potential natural vegetation: This area supports grass vegetation in the valleys and foothills and forest vegetation at higher elevations. Bluebunch wheatgrass, rough fescue, Idaho fescue, and western wheatgrass are the major grass species. Ponderosa pine, Rocky Mountain juniper, common snowberry, and skunkbush sumac are dominant species in forests.

58A—Northern Rolling High Plains, Northern Part
Montana and Wyoming

Land use: Most of this area consists of privately owned ranches. The remainder is federally owned. Most of it is in native grasses and shrubs grazed by cattle and sheep. The rest is mainly dryfarmed to wheat. Narrow strips of land along the Yellowstone River and its main tributaries are irrigated. Sugar beets, alfalfa, other hay crops, and corn for silage are the principal crops. Some of the land is in tame pasture. The upper slopes and tops of some of the higher buttes and mountains are open woodland.

Elevation and topography: Elevation generally ranges from 900 to 1,800 m, increasing from east to west and from north to south, but in a few mountains it is as high as 2,100 m. These dissected plains are underlain by shale, siltstone, and sandstone. Slopes are mostly gently rolling to steep, and wide belts of steeply sloping badland border a few of the larger river valleys. Local relief is mainly in meters to tens of meters. In places, flat-topped, steep-sided buttes rise sharply above the general level of the plains.

Climate: Average annual precipitation—300 to 500 mm in most of the area and as much as 750 mm in the mountains, but it fluctuates widely from year to year. Maximum precipitation is in spring and early in autumn. Precipitation in winter is snow. Average annual temperature—4 to 7 °C. Average freeze-free period—120 to 140 days.

Water: The low and erratic precipitation is the principal source of water for agriculture. Water for livestock is stored in small reservoirs, but supplies are inadequate for significant irrigation. Irrigation water in quantity is available only along the Yellowstone River and one or two of its larger tributaries. Groundwater is scarce in most of the area, but locally sand and gravel deposits and coal beds yield small to moderate amounts.

Soils: Most of the soils are Orthents, Orthids, Argids, Borolls, and Fluvents. They are medium- to fine-textured, shallow to deep, and mainly well-drained. Most of these soils have a frigid temperature regime, but soils in some wide river valleys, such as the Yellowstone River Valley, have a mesic temperature regime. The nearly level to steep Torriorthents (Lisam, Cabbart, and Lambeth series), Camborthids (Yamac, Lonna, and Cambeth series), Calciorthids (Crago and Cargill series), Haplargids (Bonfri series), Natrargids (Absher series), and Argiborolls (Tanna, Ethridge, and Evanston series) are on sedimentary uplands, fans, terraces, and foot slopes. The nearly level Torrifluvents (Havre and Glendive series) are on flood plains and low stream terraces.

Potential natural vegetation: This area supports grassland vegetation. Western wheatgrass, bluebunch wheatgrass, green needlegrass, and needleandthread are dominant species. In the eastern part of the area, little bluestem replaces bluebunch wheatgrass as the dominant species.

58B—Northern Rolling High Plains, Southern Part
Montana and Wyoming

Land use: More than two-thirds of this area is ranches. Most of the remainder is federally owned. Nearly 80 percent of the area consists of native grasses and shrubs grazed by cattle and sheep. Gently sloping deep soils, making up about 4 or 5 percent of the area, are dryfarmed to wheat. Narrow strips of land along the Tongue, Powder, and Platte Rivers and some of their tributaries are irrigated. Alfalfa, other hay crops, and feed grains are the principal crops. Some tracts are in tame pasture. The upper slopes and tops of some of the higher buttes and mountains are open woodland.

Elevation and topography: Elevation generally ranges from 900 to 1,800 m, increasing gradually from north to south, but in a few buttes it is as high as 2,100 m. These dissected plains are underlain by shale and sandstone. Slopes are mostly gently rolling to steep, and wide belts of steeply sloping badland border a few of the larger river valleys. Local relief is mainly in tens of meters. In places, flat-topped, steep-sided buttes rise sharply above the general level of the plain.

Climate: Average annual precipitation—300 to 475 mm in most of the area but it fluctuates widely from year to year. Maximum precipitation is in spring and early autumn. Precipitation in winter is snow. Average annual temperature—7 to 9 °C. Average freeze-free period—100 to 130 days.

Water: The low and erratic precipitation is the principal source of water for agriculture. Water for livestock is stored in small reservoirs, but supplies are inadequate for significant irrigation. Irrigation water in quantity is available only along the major rivers and some of their larger tributaries. Groundwater is scarce in most of the area, but in places, sand and gravel deposits and coalbeds yield small to moderate amounts.

Soils: Most of the soils are Orthents, Orthids, Argids, and Fluvents. They are moderately coarse to fine-textured, welldrained, and have a mesic temperature regime. The nearly level to steep, shallow to deep Tomorthents (Kim, Thedalund, Samsil, Shingle, and Tassel series) and the nearly level to steep, moderately deep to very deep Haplargids (Cushman, Olney, Terry, and Vona series) are on sedimentary uplands. The nearly level to moderately sloping, moderately deep to very deep Camborthids (Zigweid and McRae series) and Paleargids (Bidman and Briggsdale series) are on alluvial fans, foot slopes, and terraces. The nearly level, deep Torrifluvents (Haverson, Glenberg, and Bankard series) are on flood plains and low stream terraces.

Potential natural vegetation: This area supports grassland vegetation. Rhizomatous wheatgrasses, green needlegrass, needleandthread, blue grama, and threadleaf sedge are dominant species on deep soils. Bluebunch wheatgrass and little bluestem are major species on shallow soils on hills and ridges. Basin wildrye, green needlegrass, rhizomatous wheatgrasses, and shrubs are dominant along bottom land and streams. Big sagebrush is the dominant shrub.

APPENDIX B: MULTI-RESOLUTION LAND CHARACTERISTICS (MRLC) CONSORTIUM DATA DESCRIPTION

Land Cover Classes:

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low-Intensity Residential
22 High-Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Nonnatural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

Land Cover Classification System and Land Cover Class Definitions:

Water – All areas of open water or permanent ice/snow cover.

11. Open Water – areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow – all areas characterized by yearlong cover of ice or snow.

Developed – Areas characterized by high percentage (approximately 30percent or greater) of constructed materials (e.g., asphalt, concrete, buildings).

21. Low-Intensity Residential – areas with a mixture of constructed materials and vegetation. Constructed materials account for 30 to 80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high-intensity residential areas.

22. High-Intensity Residential – heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to 100 percent of the cover.

23. Commercial/Industrial/Transportation – infrastructure (e.g., roads, railroads) and all highways and developed areas not classified as High-Intensity Residential.

Barren – Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay – perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits – areas of extractive mining activities with significant surface expression.

33. Transitional – areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g., fire, flood).

Vegetated Natural Forested Upland – Areas characterized by tree cover (natural or seminatural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25 to 100 percent of the cover.

41. Deciduous Forest – areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest – areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest – areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland – Areas characterized by natural or seminatural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland – areas dominated by shrubs; shrub canopy accounts for 25 to 100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases where the cover of other life forms (e.g., herbaceous or trees) is less than 25 percent, and shrub cover exceeds the cover of the other life forms.

Nonnatural Woody – Areas dominated by nonnatural woody vegetation; nonnatural woody vegetative canopy accounts for 25 to 100 percent of the cover. The nonnatural woody classification is subject to the availability of sufficient ancillary data to differentiate nonnatural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other – orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland – Upland areas characterized by natural or seminatural herbaceous vegetation; herbaceous vegetation accounts for 75 to 100 percent of the cover.

71. Grasslands/Herbaceous – areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but are often utilized for grazing.

Herbaceous Planted/Cultivated – Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75 to 100 percent of the cover.

81. Pasture/Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops – areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains – areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow – areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses – vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands – Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - areas where forest or shrubland vegetation accounts for 25 to 100 percent of the cover, and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands – areas where perennial herbaceous vegetation accounts for 75 to 100 percent of the cover, and the soil or substrate is periodically saturated with or covered with water

APPENDIX C: MONTANA NARRATIVE WATER QUALITY STANDARDS

Montana Narrative Water Quality Standards (ARM 17.30.637)

(1) State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:

(a) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
(b) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;
(c) Produce odors, colors or other conditions as to which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;
(d) Create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; and
(e) Create conditions which produce undesirable aquatic life.

(2) No wastes may be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards.

(3) Leaching pads, tailing ponds, or water, waste, or product holding facilities must be located, constructed, operated and maintained in such a manner and of such materials so as to prevent the discharge, seepage, drainage, infiltration, or flow which may result in the pollution of surface waters. The department may require that a monitoring system be installed and operated if the department determines that pollutants are likely to reach surface waters or present a substantial risk to public health.

(a) Complete plans and specifications for proposed leaching pads, tailing ponds, or water, waste, or product holding facilities utilized in the processing of ore must be submitted to the department no less than 180 days prior to the day on which it is desired to commence their operation.
(b) Leaching pads, tailing ponds, or water, waste, or product holding facilities operating as of the effective date of this rule must be operated and maintained in such a manner so as to prevent the discharge, seepage, drainage, infiltration or flow which may result in the pollution of surface waters.

(4) Dumping of snow from municipal and/or parking lot snow removal activities directly into surface waters or placing snow in a location where it is likely to cause pollution of surface waters is prohibited unless authorized in writing by the department.

(5) Until such time as minimum stream flows are established for dewatered streams, the minimum treatment requirements for discharges to dewatered receiving streams must be no less than the minimum treatment requirements set forth in ARM 17.30.635(2) and (3).

(6) Treatment requirements for discharges to ephemeral streams must be no less than the minimum treatment requirements set forth in ARM 17.30.635(2) and (3). Ephemeral streams are subject to ARM 17.30.635 through 17.30.637, 17.30.640, 17.30.641, 17.30.645 and 17.30.646 but not to the specific water quality standards of ARM 17.30.620 through 17.30.629.

(7) Pollution resulting from storm drainage, storm sewer discharges, and non-point sources, including irrigation practices, road building, construction, logging practices, over-grazing and other practices must be eliminated or minimized as ordered by the department.

(8) Application of pesticides in or adjacent to state surface waters must be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 80, chapter 8, MCA) and the Federal Environmental Pesticides Control Act (7 USC 136, et seq., (Supp. 1973) as amended).

Excess pesticides and pesticide containers must not be disposed of in a manner or in a location where they are likely to pollute surface waters.

(9) No pollutants may be discharged and no activities may be conducted which, either alone or in combination with other wastes or activities, result in the total dissolved gas pressure relative to the water surface exceeding 110% of saturation.

APPENDIX D: MDEQ PROPOSED EC AND SAR STANDARDS

August 29, 2002 Standards (Old Proposed Standards)

The proposed SAR standard varies depending on the salinity of the water. Under the proposed standards, the instantaneous SAR in a waterbody may not exceed the value given by the equation [(EC*0.0071) – 2.475]. At an EC of 350 µS/cm or less, the formula indicates that the allowable SAR is less than zero. Because of this nonsensical result, the formula does not apply when the EC is 350 µS/cm or less. When the formula given above for calculating the proposed SAR standard results in a value greater than 5, the SAR standard is 5. The proposed formula and conditions for SAR apply year-round to all waters in the Powder River watershed.

Table D-1. August 29, 2002 proposed EC standards for agricultural uses (µS/cm).

Waterbody	April 1–October 31 (Growing Season)	November 1–March 31 (Non-growing Season)
Little Powder River, Main stem	1,900	2,000
Little Powder River, Tributaries	500	2,000
Powder River, Main stem	1,900	2,000
Powder River, All Other Tributaries	500	2,000

December 6, 2002 Standards (New Proposed Standards)

Table D-2. December 6, 2002 proposed EC standards for agricultural uses (µS/cm).

Waterbody	March 2–October 31 (Growing Season)	November 1–March 1 (Non-growing Season)
Little Powder River, Main stem	2,000	2,500
Little Powder River, Tributaries	500	500
Powder River, Main stem	2,000	2,500
Powder River, All Other Tributaries	500	500

Table D-3. December 6, 2002 proposed SAR standards for agricultural uses.

Waterbody	March 2–October 31 (Growing Season)	November 1–March 1 (Non-growing Season)
Little Powder River, Main stem	5.0	7.5
Little Powder River, Tributaries	5.0	5.0
Powder River, Main stem	5.0	7.5
Powder River, All Other Tributaries	5.0	5.0

APPENDIX E: COMPARISON OF THE PROPOSED EC AND SAR STANDARDS

Montana Proposed EC and SAR Criteria

On August 29, 2002, the Montana Board of Environmental Review proposed numeric water quality standards for the Tongue River and the Powder River, Little Powder River, Rosebud Creek and their tributaries for electrical conductivity (EC) and sodium adsorption ratio (SAR). All available water quality data are compared to these proposed standards in the main text of this document. On December 6, 2002, the Montana Board of Environmental Review instructed DEQ to prepare a supplemental notice of rulemaking regarding the adoption of numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for EC and SAR. This supplemental notice included a revised set of numeric criteria for EC and SAR. Insufficient time was available to modify this document to include consideration of these revised criteria. Major changes included in the December 6 proposed standards are described below.

- The definition of the growing season is now March 2 – October 31. The growing season was previously defined as April 1 – October 31.
- SAR standards are now fixed numbers. SAR standards were previously calculated using a formula that incorporated the EC at the time of sampling.
- The non-growing season EC criterion for tributaries to the Powder River is now 500 µS/cm.
- Both the EC and SAR standards are now based on monthly averages. Standards were previously treated as maximum allowable values for single samples.

A preliminary analysis of the December 6, 2002 standards is presented in the tables and figures below. These are referred to as the *"new proposed standards"* in the figures. Further analysis and discussion of these results will be presented in the final TMDL document.

Electrical Conductivity (EC)

Table E-1. Summary of EC exceedances, lower Powder River.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	2,000	315	154	49%	47	24	51%
Non-Growing Season	2,500	129	35	27%	15	1	7%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-2. Summary of EC exceedances, upper Powder River.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	2,000	260	115	44%	31	12	39%
Non-Growing Season	2,500	88	13	15%	10	0	0%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-3. Summary of EC exceedances, Little Powder River.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	2,000	45	38	84%	18	14	78%
Non-Growing Season	2,500	11	6	55%	4	4	100%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-4. Summary of EC exceedances, Mizpah Creek.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	500	78	41	53%	0	NA	NA
Non-Growing Season	500	34	19	56%	0	NA	NA

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

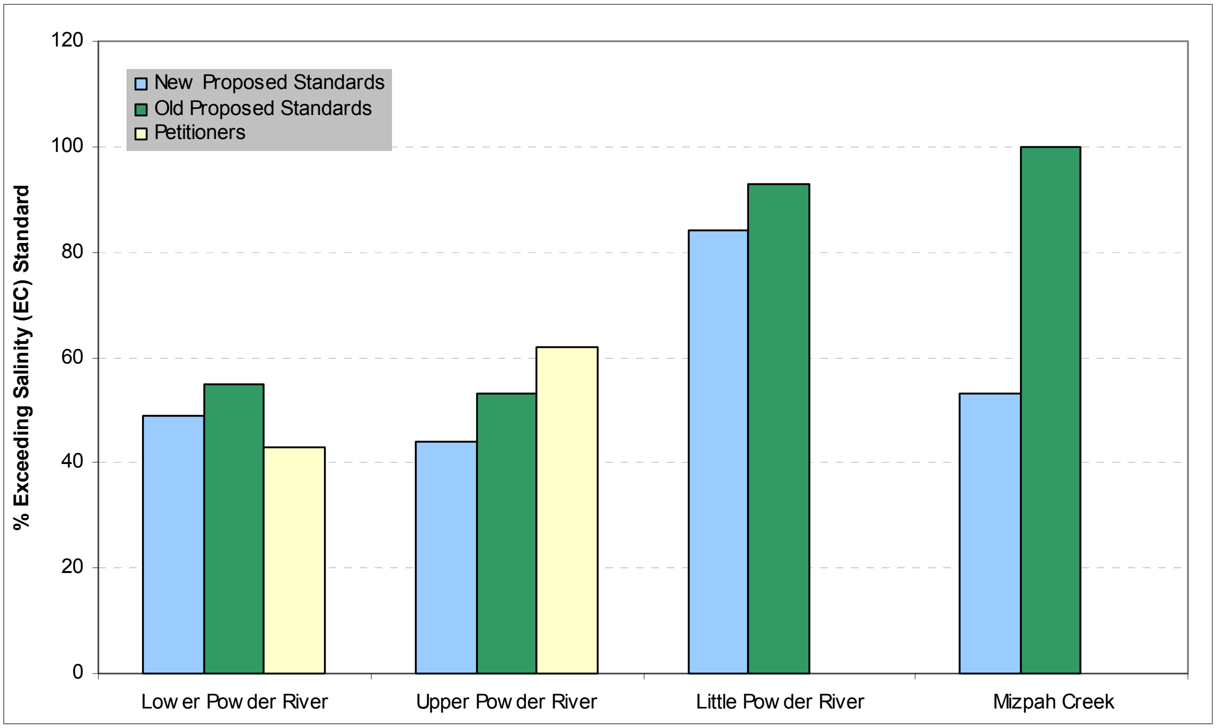

Figure E-1. Summary of salinity (EC) exceedances in the Powder River watershed during the growing season.

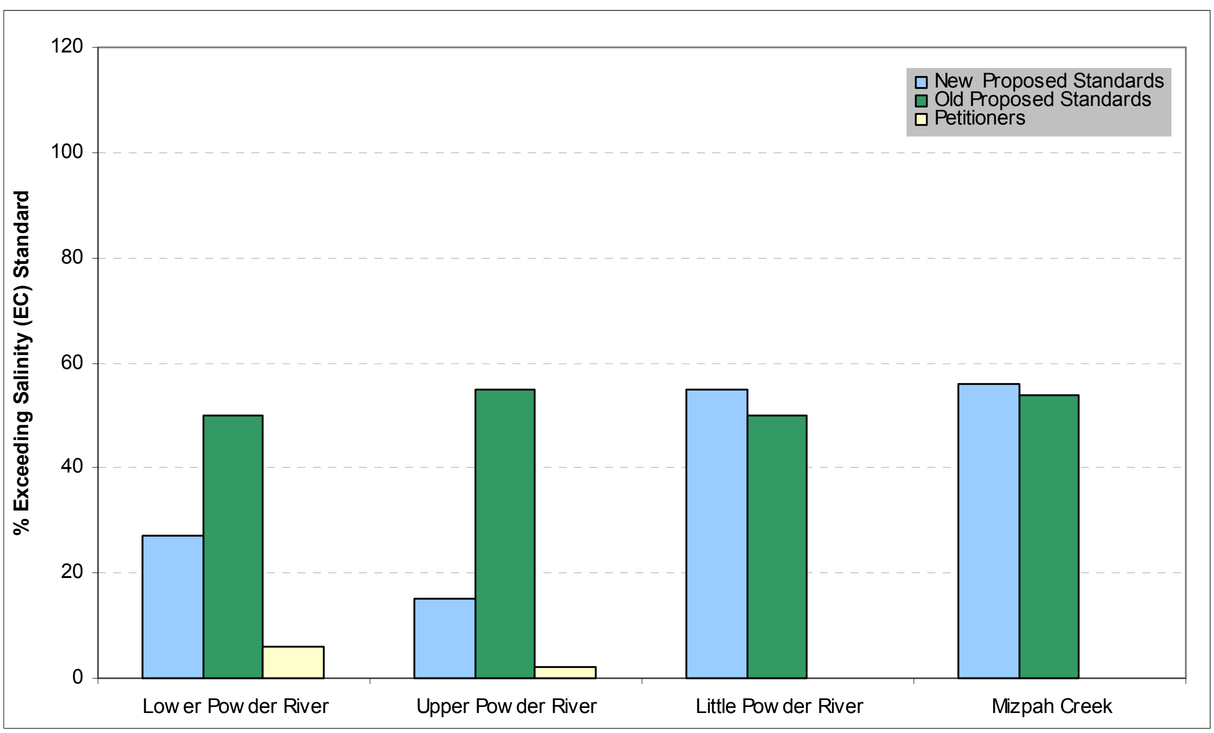

Figure E-2. Summary of salinity (EC) exceedances in the Powder River watershed during the non-growing season.

SAR

Table E-5. Summary of SAR exceedances, lower Powder River.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	5.0	212	101	48%	29	13	45%
Non-Growing Season	7.5	83	0	0%	7	0	0%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-6. Summary of SAR exceedances, upper Powder River.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	5.0	140	57	41%	14	8	57%
Non-Growing Season	7.5	55	0	0%	3	0	0%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-7. Summary of SAR exceedances, Little Powder River.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	5.0	34	33	97%	6	6	100%
Non-Growing Season	7.5	10	6	60%	4	1	25%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-8. Summary of SAR exceedances, Mizpah Creek.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	5.0	49	47	96%	0	NA	NA
Non-Growing Season	5.0	21	15	71%	0	NA	NA

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

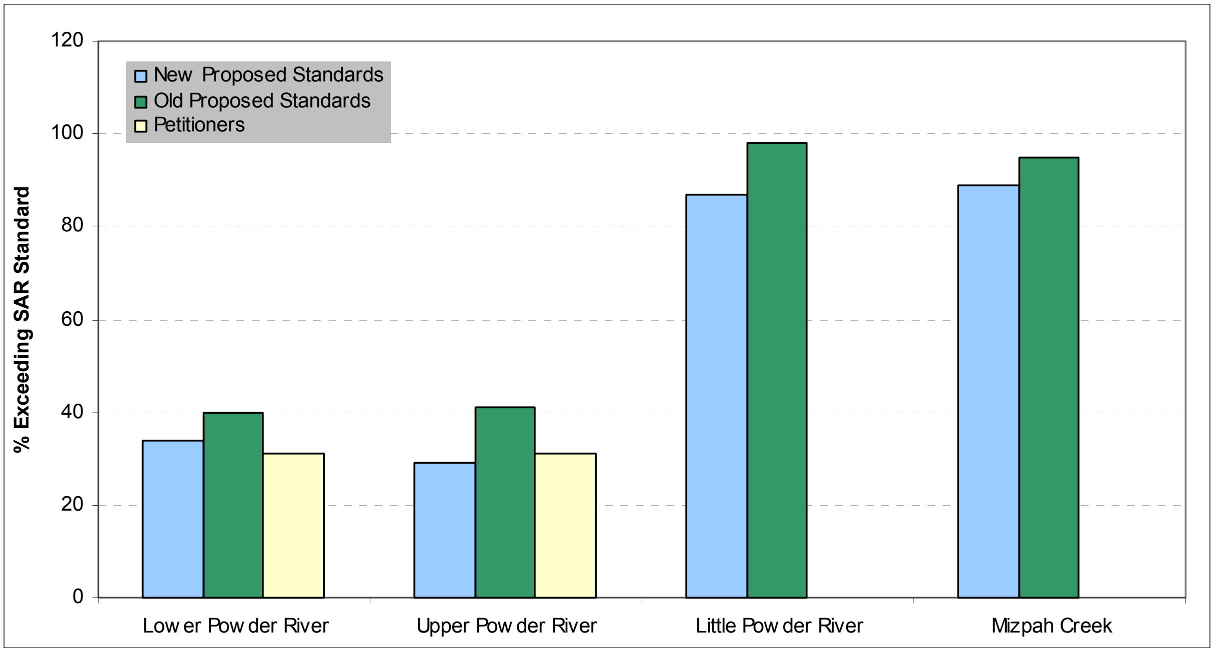

Figure E-3. Summary of SAR exceedances in the Powder River watershed, all seasons.

APPENDIX F: COEFFICIENTS FOR CALCULATING METALS STANDARDS FOR SURFACE WATERS

COEFFICIENTS FOR CALCULATING METALS STANDARDS FOR SURFACE WATERS IN MONTANA

Table F-1. Coefficients for calculating metals standards in Montana.

Parameter	ma	ba	mc	bc
Cadmium	1.0166	-3.924	0.7409	-4.719
Copper	0.9422	-1.700	0.8545	-1.702
Chromium (III)	0.819	3.7256	0.819	0.6848
Lead	1.273	-1.46	1.273	-4.705
Nickel	0.846	2.255	0.846	0.0584
Silver	1.72	-6.52	—	—
Zinc	0.8473	0.884	0.8473	0.884

Note: If the hardness is < 25 mg/L as $CaCO_3$, the number 25 must be used in the calculation. If the hardness is greater than or equal to 400 mg/L as $CaCO_3$, 400 mg/L must be used in the calculation.

Acute Standard = exp.{ma[ln(Hardness)] + ba}
Chronic Standard = exp.{mc[ln(Hardness)] + bc}

WYOMING

Table F-2. Wyoming metals standards for hardness dependant parameters.*

Parameter	Acute	Chronic
Cadmium	e^ (1.128 [ln(hardness)]-3.6867)(CF)	e^ (0.7852 [ln(hardness)]-2.715)(CF)
Chromium (III)	e^ (0.8190 [ln(hardness)] +3.7256)(0.316)	e^ (0.8190 [ln(hardness)]+0.6848)(0.860)
Copper	e^ (0.9422 [ln(hardness)]-1.700)(0.960)	e^ (0.8545 [ln(hardness)]-1.702)(0.960)
Lead	e^ (1.273 [ln(hardness)]-1.460)(CF)	e^ (1.273 [ln(hardness)]-4.705)(CF)
Manganese	e^ (0.7693[ln(hardness)]+4.4995)	e^ (0.5434[ln(hardness)]+4.7850)
Nickel	e^ (0.8460 [ln(hardness)]+2.255)(0.998)	e^ (0.8460 [ln(hardness)]+0.0584)(0.997)
Silver	e^ (1.72 [ln(hardness)]-6.52)(0.85)	N/A
Zinc	e^ (0.8473 [ln(hardness)]+0.884)(0.978)	e^ (0.8473 [ln(hardness)]+0.884)(0.986)

*Hardness measured as mg/L $CaCO_3$. Hardness values used in these equations must be between 25 mg/L and 400 mg/L. For hardness values less than 25 mg/L, use 25. For hardness values greater than 400 mg/L use 400.

Conversion Factors: Aquatic life values for the following metals are based on dissolved amounts of each substance. Because the National Toxics Criteria (EPA's Section 304(a) criteria) are expressed as "total recoverable" values, the application of a conversion factor (CF) is necessary to convert from "total recoverable" to "dissolved." Furthermore, the toxicity of the associated metals varies with hardness and the TR value must be calculated based on the $CaCO_3$ hardness prior to multiplying by the CF.

Table F-3. Conversion factors for selected metals.

Metal	Acute Value	Chronic Value
Chromium (III)	0.316	0.860
Copper	0.960	0.960
Nickel	0.998	0.997
Silver	0.85	NA
Zinc	0.978	0.986

The CF for cadmium and lead are not constant but vary with hardness ($CaCO_3$). They can be calculated using the following equations:

Cadmium Acute: CF = 1.136672 - [(ln hardness)(0.041838)]

Cadmium Chronic: CF = 1.101672 - [(ln hardness)(0.041838)]

Lead Acute and Chronic: CF = 1.46203 - [(ln hardness)(0.145712)

EPA STANDARDS

Equations for the calculation of acute and chronic standards:

$$CMC_{(dissolved)} = CF \times e^{m_a(\ln hardness)+b_a}$$

$$CCC_{(dissolved)} = CF \times e^{m_c(\ln hardness)+b_c}$$

Table F-4. USEPA equations and conversion factors for metals.

Parameter	m_a	b_a	m_c	b_c	Conversion Factors (CF)	
					Acute	Chronic
Cadmium	1.128	-3.6867	0.7852	-2.715	1.136672-[ln (hardness)(0.041838)]	1.101672-[ln (hardness)(0.041838)]
Chromium III	0.8190	3.7256	0.8190	0.6848	0.316	0.860
Copper	0.9422	-1.700	0.8545	-1.702	0.960	0.960
Lead	1.273	-1.460	1.273	-4.705	1.46203-[ln (hardness)(0.145712)]	1.46203-[ln (hardness)(0.145712)]
Nickel	0.8460	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.52	—	—	0.85	—
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986